

# INDEX

## ALCOHOL CAN BE A GAS!

- A. awamori*, 94  
abalone, 294–295  
Abbey, Edward, 1f  
ABE, 439  
abiotic oil, 61  
above-ground fuel tanks, 269, 269f  
absorption, 35  
acceleration  
  combustion and, 344  
  engine conversion and, 328, 331, 529  
  unmodified vehicle tests and, 331  
accelerator pump, 354, 369–372  
acetaldehyde, 348  
acetic acid, 109  
acetone, 137  
  in ABE, 439–440  
acid(s). See also acidity; fatty acids  
  bases and, 115–117  
  emergencies with, 115–116  
  sulfuric, 54, 115  
acid hydrolysis, 132  
  strong, 132–133  
  weak, 132–133, 134, 136, 137  
acid rain, 54, 57–58  
acidic/low-proof alcohol, 353, 354  
acidity, fermentation process and, 84  
acridine, 55–56  
Acura Integra, 389, 529–532, 531f  
additives  
  gasoline, 350, 356, 357–358, 360  
  lubrication improvement, 425  
  petroleum, 392  
Adelman, H.G., 454  
ADM. See Archer Daniels Midland  
adsorption, 226–229  
advance, ignition systems, 404–405  
adventitious, 120, 128f  
AGE-85, 337  
agitation  
  cooking and, 246–249  
  definition of, 246  
distillation, 251–256  
drive belt sheaves for, 248  
feedstock fermentation, 94, 99, 101, 105,  
  249–251, 481  
agitators, 94, 105, 112, 232, 234–235, 244,  
  246–250  
  chain drive, 489  
  motor, 249, 254  
  tanks and, 249f  
  vaporized alcohol-fueled engine for, 421f  
agribusiness, 513  
agriculture. See also permaculture;  
  polyculture  
  community-supported (CSA), 503–505  
  integrated food/energy, 513  
  organic, 46–50, 317  
  protein and, 31–32  
U.S. corn, 27, 27f, 31–32, 31f, 39–40  
*Agrocybe aegerita* (mushroom), 314f  
Agrol, 18  
Agrol Company, 17, 18  
air conditioners  
  cogenerators as, 445  
  heat pumps compared to, 218, 219  
  household cogenerated, 445  
  ice block, 447  
air pollution, 34–35, 56  
  catalytic converters and, 379  
  coal and, 57–58  
  exhaust, 425  
  neat ethanol reducing, 350  
  small engine, 421  
  stoichiometric ratios and, 379–380  
  two-stroke engines and, 425  
  wood smoke, 224, 339  
aircraft  
  alcohol-fueled, 17, 73, 73f, 337–338, 337f  
  engines of, 336–339  
  vaporized alcohol fuel and, 336, 338, 339  
airflow engine tuner, 377f, 387  
  fuel delivery increase by, 387  
air/fuel ratio, 388, 400, 410, 528  
  calculating, 364  
  carburetion and, 364, 367, 368–369  
  enriching/adjusting, 339, 365, 367, 368–  
  369, 383, 410, 424, 529  
gasoline, 364, 379–380, 380f  
metering jet determining, 364  
oxygen sensors/catalytic converters and,  
  379–380  
range of, 529  
stoichiometric ratio as, 364  
temperature and, 410  
utility engine, 424  
air-to-air heat exchangers, 302  
Alaska, 152  
  pipeline, 57f  
Alberta, oil processing sites in, 52–53  
alcohol, 9. See also alcohol fuel; alcohol  
  production; alcohol production  
  process; ethanol; ethanol v. gasoline;  
  proof  
  beverage, 206, 208, 469  
  boiling point of water and, 185, 191  
  combustion of, 35, 446  
  cooking food with, 339–341  
  cooling with, 447  
  denatured/denaturants for, 268, 270–271,  
  274, 327, 394, 429, 500  
  developing countries and, 41, 339–341,  
  340f  
  dry/drying, 225, 226–227, 227f, 236–237  
  dual markets for, 71  
  enrichment of, 192, 192f, 194, 206  
  flashpoint of, 268, 269f  
  forms of, 437  
  generator using, 444  
  household power use of, 446–448  
  industrial-grade, 206  
  leakage of, 268  
  lighting with, 447  
  liquid, 210  
  off-road uses for, 196–197, 339–341, 444,  
  462  
  oxygen content of, 347  
  phase separation of, 225–226  
  prairie v. corn, 42  
  proof requirement and, 196–197  
  reforming, 431  
  sources for, 119–180  
  storage of, 232, 268–274, 268f, 271f  
  sugar, 136  
  vaporized, 66, 331f, 332–333, 418  
wood, 437  
  yield calculation for, 111–112  
alcohol dryer, 227f  
alcohol fuel. See also blend(s); dual-fuel  
  capability; engine conversion;  
  ethanol; proof; specific blends  
aircraft using, 17, 73, 73f, 337–338, 337f  
air/fuel ratio for, 339, 365, 367, 368–369,  
  383, 410, 424, 529  
alcohol pumps for, 430  
average latent heat of, 344  
blends of, 16, 70, 328, 356–357, 450–451  
Brazil export of, 41  
carburetors and, 363–375, 364f  
castor oil and, 426, 451, 452  
cogeneration using, 441–446  
diesel blended with, 450–451  
engines built for, 333–336  
fuel injection and, 379  
fuel needs supplied by, 27, 27f  
gasoline mixed with, 225–226, 375, 431  
legal definition of, 430, 500  
low-proof/acidic, 353, 354  
mad cow disease and, 316  
mileage and, 263, 351–353  
myths about, 24–37  
octane in, 337, 435  
100%, 333–336  
peak power of, 336  
polyculture production of, 29, 39–40  
price of, factors in, 459, 463, 501  
redefining, 500  
refrigerators, 341  
safety of, 356  
sale of, 33  
temperature, 410  
vaporization of, 332, 333f, 341, 399, 409–  
  410, 418, 425  
vehicle warranties and, 468–469  
water content of, 356

world use of, 70  
alcohol history, 9–21  
Alaska pipeline and, 20  
Argol and, 17  
biodiesel and, 14  
FFVs and, 429–431, 432  
gasoline and, 12, 15  
Germany and, 11, 14, 18  
the Great Depression and, 15–17  
lichens and, 152  
Nazis and, 18  
post-WW II to present, 19–21  
potato alcohol and, 170  
propaganda and, 16, 17  
stills/distillation in, 191–194  
vaporization and, 332  
Whiskey Rebellion and, 9–11  
WW I, 14–16  
WW II, 17–19  
alcohol movement, 496  
CSA and, 512  
alcohol production. See also alcohol production process; distillation; energy crops  
alleged sewage from, 297  
aquaculture combined with, 289–294  
Brazil's, 69–73  
business practices for, 457–458  
economic considerations in, 458–465, 460–461/  
employment and, 34, 318, 320, 340, 513  
incentives for, 497–498  
integrated, 510–512  
land for, 27–29, 157  
legalities of, 469–471  
protein concentration from, 94, 277  
scale of, 69–73, 227, 308  
sugarcane for, 29, 171, 211, 298  
value-added, 512  
alcohol production process, 75–116. See also distillation; fermentation; yield  
advanced techniques for, 112–115, 113/  
feedstock fermentation in, 83–115  
feedstock selection in, 77–82  
pressure/vacuum in, 187  
yield calculation in, 111–112  
alcohol pumps, 72/  
alcohol fuel and, 430  
Brazilian, 72/  
alcohol yield(s), 202, 462. See also specific crops  
batch distillation example of, 484  
beets v. corn, 27  
calculating, 111–113  
continuous distillation, 197  
distillery size and, 197  
energy crop, 42, 119  
feedstock, 27, 27/  
fruit v. starch, 80  
large-scale, 458  
root crop, 145  
SCP, 305  
soil microlife and, 48–49, 49/  
sugarcane, 170–171  
aldehyde, 204. See also acetaldehyde  
in ethanol emissions, 348  
Alyeska pipeline, 57  
algae, 268. See also marine algae  
DDGS and, 293  
spirulina variety, 292–293  
alkaline, 58  
pH 84–85, 91–93

safety, 115, 117  
alkaline lime, 58  
alkylates, 355  
allyl mercaptan (garlic extract), 500  
alpha amylase, 92–95, 97–99, 101/, 112–113, in barley malt, 115  
alternative fuel. See renewable fuel  
altitudes, pressures at various, 540/  
Amazon, 73  
American Gas Association, marine algae study by, 157  
American Home Grown Fuel, 2  
American Petroleum Institute (API)  
propaganda by, 16, 17, 25, 26, 350, 463  
American Public Transportation Association, 32  
American Type Culture Collection, 109, 152  
amino acids, 104,  
mushrooms and, 286–288  
single-cell protein and, 305–306  
model farm and, 313–316  
ammonia refrigerators, 447  
amphibians, Roundup herbicide and, 131  
anaerobic  
phase in fermentation, 102,  
making methane in ponds, 267  
methane digester, 297–298  
anhydrous alcohol, 225–226  
animal(s)  
milk of, distiller's feeds increasing, 281  
protein sources for, 122, 138, 158, 286–287  
ruminant, 121  
weight gain in, 280–281  
animal feed. See also distiller's feeds  
byproducts for, 86, 116, 278  
corn as, 31–32, 143–144  
feedstocks suitable for, 121, 122, 138, 147, 160, 163  
fodder beets as, 147  
fruit pulp as, 86  
mushroom, 288, 314  
plant-based, 287  
protein in, 122, 138, 286–287, 293  
storage and, 261  
untreated/wet, 261  
yeast, 306–307  
annealing, 412  
annuals, 26  
and tilling, 166  
annual gallon of production capacity, 33, 34, 137  
antifreeze, 443  
Anti-Saloon League, 15  
anti-tamper device, removal of, 383–384  
Anvil Points plant, 55  
API. See American Petroleum Institute  
aquaculture, 289–294  
aquifer, 56, 71  
Archer Daniels Midland (ADM), 228, 317, 454  
CO<sub>2</sub> enrichment use by, 300, 301, 311/  
tilapia production model of, 283, 290–292  
Arctic National Wildlife Refuge, 20  
Arnold, Thurman, 18  
aromatic, 357–358  
aromatic hydrocarbons, 350  
*Aspergillus niger*, 94  
aspirators, vacuum from, 216  
atmospheric distillation, 187, 214  
proof maximum in, 225  
surplus heat storage in, 189

atmospheric distillery,  
compared to vacuum distillery, 189, 214–215  
atmospheric pressure, 155  
atomization, 408, 409, 410  
auger dewatering press, 234, 237, 263, 279  
auto companies  
engine designs of, 359  
oil companies/CAFE credits and, 430–431  
auto-ignition point, 358, 450  
auto racers, 422–423  
methanol use by, 344, 438  
automotive analyzer, 369/  
average latent heat, ethanol v. gasoline, 344  
aviation industry, fuel costs of, 336–337  
azeotropic distillation, 225–228  
advanced forms of, 227–228  
back-flush system, 255–256  
backslop, 89. See spent mash  
bacteria. See also microflora; microlife; single-cell protein  
algae and, 292  
butanol fermentation, 439  
cellulose digestion of, 132/  
compost and, 284–285  
dewatering with, 304–305  
distiller's solubles for, 304–305  
GMO, 135, 140  
growing, 237  
mash contaminated by, 106, 106/, 255, 484, 489  
methane-producing, 266, 297  
piping/plumbing and, 255  
rain dances and, 135  
silage and, 279  
storage of, 306  
bacterial enzymes, fungal combined with, 113  
bagasse  
cellulose processing of, 137  
cogeneration and, 25/  
Bakhtiari, Ali Samsam, 344  
baking soda, 116  
Baldwin, Leland, *Whiskey Rebels: The Story of a Frontier Uprising*, 9  
ball valve, 200, 256, 269  
balling hydrometer, 90  
bananas, 111, 173, 175  
barley malt, 113–115  
as yeast nutrient, 89  
barrel (oil), 19, 51, 54  
barstock, 224, 232/  
barter system, for co-products, 459–460  
Bartlett, Roscoe, 469  
bases, acids and, 115–117  
batch distillation, 195–206  
reboilers and, 217  
batch method (fermentation), 96–102  
and heat exchangers, 235  
batch plant, 87. See batch method  
Battelle Institute, 175  
Bates, E., 339  
BATF. See Bureau of Alcohol, Tobacco, and Firearms  
batteries, heat tank, 188–190, 444  
Bayh, Birch, 19  
bearings, 241  
ethanol myths and, 356  
high compression and, 417  
beef cattle, 280–281  
beer, 1, 12

- beets, 78  
 corn v., 27  
 fodder, 119f, 144–147  
 sugar, 165–167, 298  
 before top dead center (BTDC), 401, 401f  
 Behnken, Jim, 327–328, 337  
 belt-driven fans, 345–346  
 benzene,  
   in distillation, 226–228,  
   in BTX, 348, 350, 355, 357, 426  
 berm, 28, 44f  
   for sugarcane in Brazil, 71  
 Berry, Wendell, 435  
 beta amylase, 94, 100  
   in barley malt, 114, 115  
 beverage alcohol, 206, 208, 469  
 bicycles, 56  
 Bilmes, Linda, 496  
 biocides, 48  
 biodiesel  
   alcohol fuel mixed with, 418  
   biological, 440  
   diesel and, 73–74, 450–451  
   hazelnut, 138  
   history of, 14  
   lubrication, 426–427  
   marine algae and, 154  
   methanol and, 439  
   misleading name of, 439  
   palm oil as, 73, 160  
   permaculture production of, 440  
 biofilter, chives for nitrogen removal, 291  
 biofuel, 20, 307–308, 440, 450. See also  
   biomass  
   boilers using, 26  
   distillation using, 202  
   polyculture, 42  
 Biofuels Security Act, 20  
 biological biodiesel, 440  
 biological oxygen demand (BOD)  
   in cattails sewage treatment, 127  
   of coffee pulp, 141  
   of stillage, 284, 297  
 biology  
   DDT/insecticides and, 45–46  
   plant life, 40–45, 83–84, 91  
 biomass, 18, 26  
   acid hydrolysis of, 132–133, 134, 136, 137  
   algae, 293  
   cellulose, 129–138  
   food cooking fire from, 339  
   methanol production and, 437  
 biomass pyramid, 43  
 biorefining, 28  
   income from small alcohol plant, 320f  
 blend(s), 16, 70, 328, 330f, 356–357  
 ABE, 439  
 AGE-85, 337  
 alcohol/water, flashpoint of, 269f  
 diesel-alcohol, 450–451  
 E-85, 70, 325–331, 360  
 ether, 427  
 FFV, 431, 433  
 5.7% ethanol v. 50/50 alcohol/gas, 330f  
 gasohol, 274, 354, 355  
 gasoline, as changing, 350  
 myths about, 356–357  
 propane/alcohol, 435–436  
 regular/premium gasoline, 357–358  
 blending octane value, 357  
 Blendsol, 426  
 blow-by, 356  
 blower  
   in wood fire, 204  
   compression increase and, 418–419  
 Bluewater Network, 52  
 BOD See biological oxygen demand  
 boilers  
   biomass-fueled, 26  
   propane, 488–489, 488f  
 boiling point(s)  
   air pressure and, 209  
   alcohol, 185, 191  
   energy sources from lowering, 210–214  
   fusel oil, 208  
   gasoline chemicals, 332  
   mash pot/chemicals, 191, 208  
   practical, 191f  
   pressure and, 187  
   proof and, 190–191  
   in strong acid hydrolysis, 132  
   surplus heat storage and, 189  
   vacuum and, 209–210, 210f  
   vapor pressure and, 185, 192  
   vaporization and, 332, 409  
   water/alcohol v. water, 185, 191, 209  
 boost pressure, 444  
 Borenstein, Severin, 219  
 boroscope, 338  
 Bosch Corporation, 377, 379  
 bottoms, 489  
 brain box, 378, 383  
 Brandt Farms distillery, 481–484  
 Brazil, 26, 69f, 450  
   aircraft of, 337–338  
   alcohol fuel production in, 69–73, 170  
   alcohol-only-vehicles in, 69, 70  
   biological fertilization in, 170–171  
   carburetors, % alcohol and, 375  
   catalytic converters in, 348  
   cellulosic alcohol and, 138  
   energy scam in, 72  
   export and, 41  
   farming in, 70–71  
   FFVs of, 74, 226, 432–433, 500  
   fooler technology of, 387  
   fuel pumps in, 72f, 333  
   historical overview of, 69–70  
   pollution drop in, 348  
   soybean production in, 170–171  
   stillage fertilizer use in, 284  
   sugarcane plantations, 30, 70, 71, 170  
   trip to, 69  
   vaporization and, 333  
 breakaway fitting, 269  
 breaker points, 400  
 breeders (poultry), 283  
 brewer's yeast,  
   as yeast nutrient, 89–90, 105  
   alcohol tolerance of, 102  
 Briarpatch Network, 457  
 British Security Coordination, 18  
 British thermal unit (Btu), 30, 186, 351  
   energy content measured by, alcohol v.  
   gasoline, 352f  
 Brix, 95  
 Brix hydrometer, 90  
 bronze wool packing, 195f, 196  
 Brown, Jerry, 2, 21  
 Btu. See British thermal unit  
 BTX, 348, 355, 357–358, 427  
 bubble cap column still, 193–194, 193f  
   with continuous still, 209  
   versus perforated plate column still, 195  
 buffered eyewash, 116  
 buffalo gourd, 120–122  
 bulk storage, 271f  
 bung wrench, on fuel tank, 271  
 Bureau of Alcohol, Tobacco, and Firearms  
   (BATF)  
   application for alcohol fuel producer  
   permit, 472–474f  
 contacting, 471  
 denaturants approved by, 500  
 history of alcohol permits, 469–470  
 alcohol regulations, 470–471  
   filling out the alcohol permit, 471, 475  
 buses, alcohol-vapor-fueled, 335  
 Bush, George H. W., 2, 3, 21, 59, 445  
 Bush, George W., 20, 32, 496  
   global warming and, 197  
   mercury credits and, 58  
 bushings  
   in agitators, 247  
   in control coils, 206, 206f  
   in cooling coils, 263f  
 business  
   agribusiness and, 513  
   alcohol fuel production, 457–458  
   byproducts, 510–512  
   feedstock contracting in, 510–511  
   green, 457  
   legal considerations for, 465–478  
   registration/application for, 461–462  
 butane tanks, 216  
 butanol, 437, 439–440  
   ABE made from, 439  
   biodiesel production using, 439, 440  
   fermentation of, 439, 440  
   sale of, 439–440  
 Butterfield, Floyd, 479–481, 480f  
 butyl rubber, 355  
 butyric acid, 109, 439  
 byproduct(s), 321. See also co-products;  
   distiller's feeds; surplus; waste  
   animal feed use of, 86, 116, 278  
   bagasse, 25, 25f, 71, 72, 137, 451  
   carbohydrates in, quality of, 287–288  
 CO<sub>2</sub> as, 237, 299–304  
 distillation, 288  
   feedstock selection and, 77, 79  
   fertilizing with, 11, 79, 286, 321  
   fodder beet, 146  
   fuel co-ops and, 510–512  
   garlic, 80  
   melon pulp, 79  
   mulch and, 141  
   paper plant, 132, 137  
   spent mash as, 11, 235, 241, 439, 440, 482  
   toxic, 132  
   urethane, 104  
   vinasse, 169  
 C5 sugars. See five-carbon sugars  
 C6 sugars. See six-carbon sugars  
 CAFE. See corporate average fuel economy  
 Caiado, Alessandra Ramos, 69  
 Calder Couplers, 482  
 Caldicott, Helen, 513  
 calf starters, 281  
 Calgene, GMO bacteria created by, 135  
 California  
   chemical banning in, 426  
   smog tests in, 541  
 California Air Resources Board (CARB), 467, 468

California Reformulated Gasoline, 330f, 358

calories, 31

cam

distributor, 400

in high compression, 416

camlock fitting

in fermentation tank, 245

in heat exchanger, 260, 262f

Campbell, Colin, 20

camshaft, in high compression 416

cancer, 30, 58, 59, 348

and shiitake mushrooms, 287

candy waste, 177

canopy, 44f, 121f

carbon dioxide with, 303

comfrey, 143

coppicing, 130

Jerusalem artichokes, 148, 149, 150

mesquite, 158

mesquite and prickly pear, 164

in polycultures, 130

soil microlife, 45

sugarcane, 71, 167, 168

sweet sorghum, 175

*Tipuana tipu*, 130

capitalism, 5, 338

Capstone microturbine, 443f

CARB. See California Air Resources Board

carbohydrates, 28, 35

alcohol byproduct, quality of, 287–288

laminarin, 153

removal of, 277

carbon dioxide ( $\text{CO}_2$ ), 28, 299–304, 312

agitation and, 249–250

byproduct, 237, 299–304

compressor, 234, 299f, 301

co-product, 31

DDG storage and, 279

drip irrigation delivery of, 303

emissions of, 35, 54

greenhouse use of, 300–302, 312

hydrogen power, 64

marine algae and, 316

methane hydrate v., 62

methane source of, 266, 293, 316

natural gas production of, 53

nuclear power and, 60–61

oil wells using, 111

petroleum and, 61

photosynthesis of, 35, 40, 42, 300, 302–303

plant life enrichment using, 300–301, 302–303, 304, 311f

sales of, 312

sequestered, 35, 42

sources of, 304

surplus, 317

uses for, 299–304

washing, 304

carbon dioxide compressor, 234, 299f, 301

carbon monoxide ( $\text{CO}$ ), 35, 329, 333f, 347, 366

carbonization, exhaust pipe, 421

carbons, alcohol number of, 437

carburetor

corrosion of, 354

dual-fuel, Model A, 12, 430f

ECU for, 528

floats, 364–365

fuel injection and, 363–364, 364f

vaporizing, 333

carburetor conversion, 355, 364–375, 364f,

373f, 407–409

accelerator pump in, 369–372

air/fuel ratio for, 364, 367, 368–369

carburetor floats in, 364–365, 373–374

cold-start systems and, 391–393

EGT gauge in, 366, 367, 367f

electronic, 374–375

exhaust gas analyzer and, 366, 368

float needles in, 425

fuel preheating in, 407–409, 408f

gaskets in, 412–413

idle circuit and, 368–369

metering jet adjustments in, 364–368, 411

motorcycle, 422

power valve adjustment for, 372–373

propane and, 335

side-draft carburetors and, 422

single-barrel, 364–365, 372f

test drive for, 365–366

throttle body fuel injection and, 369

troubleshooting chart for, 371

twin main jets, 373f

utility engine, 424, 425

vacuum gauge in, 367

vaporizing alcohol in, 331f, 335

carcinogens

ethanol v. gasoline, 348

gasoline, 357

cardlock station, 506

Cardoso, Marc, 292, 293

Carter, Jimmy, 2, 55

cashews, 176

cassava, 84, 101f, 113, 113f, 122–125, 124f, 288

batch fermentation of, 96–102, 101f

growing, 123

planting, 124

castable refractory, 222

castings, worm, 296

castor beans, as feedstock, 125–126

castor oil, 426, 451

diesel conversion using, 452

catalytic combustor, 224

catalytic converter, 328

Brazil's use of, 348

EPA and, 467

oxygen sensors and, 379–380

catalytic metals, 431

cattails, 28, 126–129, 126f

cattle, 32, 147

beef, 280–281

dairy, 281

DDG feed for, mad cow disease and, 316

disease in corn-fed, 144

distiller's feeds for, 280–281

manure of, 293, 298

yeast v. corn for, 306

Cayman Islands, 496

CDS. See condensed distiller's solubles

cellulase, 92, 133

cellulose, 18, 28–29, 119

azeotropic distillation using, 227–228

bacteria that digest, 132f

biomass technology from, 129–138

breaking down, 131–136

fermentation of, 307

glucose molecules in, 129

lignin in, 129, 287

mushroom cultivation and, 288

polyculture and, 28, 29, 512

rumen and, 280, 282

solvents for, 137–138

sources of, 130–131

cellulose digestion factors, 278

cellulosic alcohol

Brazil and, 138

credits for, 462–463

ethanol and, 136–137

cellulytic digestion, 280

Celsius, degrees 62

conversion to Fahrenheit, 533f

Center for Biology of Natural Systems, 25

Center for Food Safety, 135

Center for Public Integrity, 496

Centigrade–Fahrenheit conversion table, 533f

centrifugal pump, 251, 251f, 252f, 255

centrifuge, 96

ceramic saddles, 196

cetane, 194

improvers, 208, 450–452

rating, 335, 450–452

CGM. See corn gluten meal

chain drive agitator, 489

chainsaws, 425, 426–427

*Changes in Gasoline III, The Auto Technician's Gasoline Quality Guide*, 356

channel stock, 264–265

chaperone, mad cow disease, 281

charcoal production, methanol and, 438

check engine light, 328–329, 388, 434

chelate, 358

chemicals

cobalt chloride, 226

distillation and, 204, 206, 208

fertilizer, soil microlife killed by, 45

foreshot, 204, 206

gasoline, boiling point of, 332

regulations on, 426

chemurgist, 16, 21

Cheney, Dick, 496

chestnuts, 138–139

chicken/egg analogy, 430

chill day, 166

China, 36, 37, 70, 124, 421

air pollution from, 56

marine algae in, 153, 155

mushroom cultivation in, 286

organic farming in, 315

steel demand of, 241

tar sands bid by, 54

chisel plow, 286

chitin, 294

chives

biofilter, 291

emulsion, 291–292

chlorinated hydrocarbons, 30

choke, 12

engine conversion and, 411

in troubleshooting carburetor, 371

Chrysler, 397

CIP. See cleaning-in-place system

CIS. See constant injection system

Citizen Works, 496

citrus fruits, 139

city council, 477

civil disobedience, 465

Civil War, 11

Civilian Conservation Corps, 513

clamp-on tank mixer, 247f

Clean Air Act, 468

clean room, mushroom cultivation, 313–314

cleaning-in-place (CIP) system, 103, 110, 110f

in fuel/feed plant layout, 237, 238  
 climate  
 crops for specific, 27–28  
 feedstock fermentation and, 85  
 feedstock selection and, 78  
 fuel and, 225  
 temperate, 165  
 water supply lines and, 256  
 closed loop  
 oxygen sensor 380, 432  
*Clostridium*, 439, 440  
 CO. See carbon monoxide  
 $\text{CO}_2$ . See carbon dioxide  
 coal, 57–58, 63  
 electricity from, 57, 442  
 hybrid vehicle electricity and, 442  
 strip mines, 57f  
 cob, 221,  
 in rocket still, 221f, 223  
 cobalt chloride, 226  
 coffee  
 feedstock, 87, 139–142  
 filters, 90, 91  
 mushroom cultivation and, 42, 286, 287  
 cogeneration, 21, 71–73, 211, 441–446  
 co-ops, 447  
 definition of, 441–442  
 grid connection and, 445–446  
 home alcohol, 442, 443, 444, 446–448, 500  
 ICEs and, 442, 444  
 vehicle, 444, 445  
 cogeneration system, building, 443  
 cogenerators, 72, 258  
 coil, 89. See control coil; cooling coil; heating coil; immersion coil heat exchanger  
 coil rolling tool, 199f  
 cold-start devices, 337–338, 337f, 391–397, 418, 499  
 Acura, 527f, 529f  
 alcohol fuel need for, 360  
 automated, 393–394  
 CAFE credits and, 430–431  
 choices for, 391–392  
 diesel glow plugs, 396  
 diethyl ether, 392–395  
 fuel choice and, 529  
 fuel-adding, 392–396  
 gasoline, 392, 396f  
 mechanical fuel pump, 395–396, 396f  
 motorcycle, 423  
 nongasoline, 396–397  
 propane, 392f, 394f, 395  
 utility engine, 424  
 Coleman lantern, 396  
 collar, 381  
 column, 193  
 column control factors, packed column still, 197, 199–204  
 column stills, 194–206, 200f, 209, 228–230, 480, 486–489, 490f, 503f  
 bubble cap, 193–194, 193f  
 corn grit dehydration, 228  
 height-to-diameter ratio of, 196–197, 229  
 packed, 195–205, 195f, 202f, 209  
 perforated plate, 194–195, 209, 488–489  
 reducing height of, 229–230  
 tank size matched to, 197, 197f  
 twin-column, continuous, 486–489, 487f  
 combined heat and power, 442. See cogeneration.  
 combustion, 35. See also internal

combustion engine  
 acceleration and, 344  
 alcohol, 35, 446  
 ethanol v. gasoline, 343f, 344–347  
 heating value and, 351  
 metals for clean, 431  
 wood, 221–222, 224  
 combustion chamber, 344, 347f, 415  
 comfrey, 142–143  
 Commoner, Barry, 25, 27, 307  
 community-supported agriculture (CSA), 231, 503–512  
 community-supported energy (CSE), 34, 459, 465, 503, 505–515. See also fuel co-ops  
 CSA model for, 503–505  
 completely denatured alcohol, 509  
 complex sugars, 98  
 compost, 31, 40  
 making, 284, 285  
 stillage, 284–286  
 compost tea, 141, 142, 286, 321  
 compounds, 84  
 compressed-air-driven pump, 254, 254f  
 compression  
 $\text{CO}_2$  234, 299f, 301, 335, 450  
 compression increase, 415–419  
 mechanical approach to, 416–418  
 nonmechanical approach to, 418–419  
 compression ratio, 70, 415, 416f, 417, 429  
 Brazil v. U.S. FFVs, 433  
 diesel engine, 450  
 mileage and, 359–360  
 octane and, 358–360  
 variable, 433–435  
 compression-ignition engine, 14, 333, 334, 450  
 compressor, 56, 212. See also carbon dioxide compressor  
 in agitation, 250  
 computer ECU, 389–390  
 concentration, sugar, 85–88  
 testing, 90–92, 106–108  
 condensed distiller's solubles (CDS), 278  
 condenser, 97, 192, 198f  
 conservation vent, 226, 270f, 271  
 constant injection system (CIS), 383, 384f  
 constructed wetlands, 286  
 consumer automotive buying preferences, 352f  
 consumers  
 oil, 41f  
 tax benefits for, 461  
 contamination, 89, 109–111  
 distillery byproducts preventing, 288  
 GMO, 136  
 mash, 106, 106f, 255, 484, 489  
 oil diluted by gas as, 373, 408  
 continuous distillation, 194, 206–209  
 alcohol yield from, 197  
 distillery size and, 217  
 recycled heat in, 208  
 continuous distillery, 87–88, 479–481, 486–489, 487f  
 cost of building, 209  
 continuous stills  
 batch v., 207, 209  
 reboilers and, 194, 217–218  
 contracting, feedstock, 510–511  
 control coil, 199, 253  
 construction of, 205–206  
 control pressure, 383

conventional oil, 20, 52, 54, 350  
 conversion. See also engine conversion  
 compression and, 415–419, 416f  
 fuel oil burner, cogeneration and, 446  
 fumigation, 452–453, 452f, 453f  
 conversion, of energy, 190  
 hydrogen-electricity, 65, 65f  
 natural gas-electricity, 190  
 warm to hot water, cogeneration and, 442  
 conversion, 89. See saccharification.  
 cooker, 97, 98, 235, 487f  
 and agitators, 246–247  
 fermenter combined with, 458  
 in fuel/feed plant layout, 237, 238, 239, 242, 244  
 with vacuum distillation, 214  
 cooking. See also hydrolysis  
 advanced techniques for, 112–115  
 agitation in, 246–249  
 alcohol for food, 339–341  
 developing countries and, 339–340, 340f  
 net cooking energy consumed, 114, 114f  
 semi-continuous, 112–113  
 whole-pulp fermentation step, 88–89  
 cooling coil, 89, 93, 98–99, 103, 103f, 110, 110f, 252–253, 261  
 flow-control valve, 200f  
 packed column still, 199  
 cooling fans, 345–346  
 cooling jacket, 89, 246  
 engine, 443–444  
 cooling tower, 215, 231f, 235–236, 235f, 253  
 Cooper, Gordon, 336f, 338  
 cooperative. See fuel co-ops  
 coppicing, 29  
*Bursera simaruba* (gumbo limbo), 131  
 river red gum, 130  
*Tipuana tipu* (rosewood), 28, 130  
 woodlots, 312, 318  
 co-product(s), 25, 82. See also byproduct(s); carbon dioxide; mushroom cultivation; surplus; waste  
 alcohol production, 277–308  
 aquaculture, 289–294  
 barter system for, 459–460  
 biofuel, 307–308  
 $\text{CO}_2$  as, 31  
 coffee, 140  
 distiller's feeds, 1, 277–286, 288, 289–294, 296–298, 301, 305, 306–307, 314  
 earthworms, 295–297, 314  
 EROEI and, 25  
 fertilizer, 283–286  
 mariculture, 294–295  
 micro-plant economics example of, 459, 460–461f  
 nutrients in various, 279f  
 profitability/value of, 308  
 shrimp cultivation using, 294  
 corn  
 animal feed, 31–32, 143–144  
 cattle and, 32, 144, 306  
 cellulose of, 29, 227–228  
 as co-product, nutrient composition of, 279f  
 as energy crop, 27, 29, 143–144  
 fertilizer needed by, 143  
 median yield of, 48–49  
 organic farming of, 46–47  
 stover, 312  
 U.S. agricultural, 27, 27f, 31–32, 31f,

- 39–40  
yeast replacing, 307
- corn alcohol  
prairie v., 42  
yield of, 143
- corn gluten meal (CGM), as herbicide, 47–48
- corn starch, 112
- corn syrup, viscosity of, 544f
- corporate average fuel economy (CAFE), 12, 429–431
- corrosion  
carburetor, 354  
ethanol v. gasoline and, 353–356
- costs. See also price  
aviation industry fuel, 336–337  
azeotropic distillation, 227  
cutting plant/production, 459–461, 460–461f
- distillery, 209, 215, 216, 220, 480  
E-85 fuel, 464f  
energy, 211, 215  
feedstock credits and, example, 460–461f  
gasoline per gallon, 33  
imported oil, 18, 18f  
nuclear power plant, 61  
oxygen sensor foolers, 388  
U.S. military presence in Mideast, 496  
wood heat, 221
- countercurrent stream distillation principle, 194, 194f, 206
- counterflow heat exchanger, 233, 258–259, 261f, 424f, 425
- counterflow vaporizer, 424f
- coupling, 206f, 245, 263f
- CPVC, 256
- Crabtree effect, 88, 106, 108, 109
- crankcase oil, 428, 428f, 435
- Crawford, Ian, 491–492
- credits  
alcohol fuel retail, 496  
CAFE, 430–431  
cellulosic alcohol, 462–463  
E-85 fuel, 464f  
electricity/public utility, 446  
energy, 462–463  
feedstock expenses and, example, 460–461f  
mercury, 58  
tax, 2, 21, 312, 429, 461, 462
- crop rotation, 40, 119, 125, 175  
feedstock selection and, 78
- fodder beets, 146
- sugar beets, 165
- cropland, U.S., 26–27, 27f, 31–32, 31f
- crops. See also feedstock(s); plant life  
arid land, 27, 125, 164  
climate and, 27–28  
 $\text{CO}_2$  enrichment for, 300, 301, 302–303, 304, 311f  
energy, 27–29, 119–180, 510  
experimental, 78–79  
nitrogen-fixing, 44, 158, 163  
overstory, 138  
root, 145  
starchy, 95  
U.S. top four, protein and, 31  
wastewater for growing, 126f
- cross-linked polyethylene, 242
- cross-shade, 42
- crude oil production, 19
- CSA. See community-supported agriculture.
- CSE. See community-supported energy
- cubic feet per minute, 232
- cultivar  
prickly pear 164  
sugarcane, 166–167, 170
- cyanobacteria, 292, 304
- cyclone funnel tanks, 223f
- cylinder, 12
- engine, 32, 344, 351f, 359, 367, 370, 401, 413, 416, 426–427  
screen, 263  
stave, 263–264
- cylinders,  
in vaporizing alcohol engine, 427
- cylinder heads, two-stroke engines, 427
- cylindrical tanks, gallonage of, 243f, 244
- Dailey, Jack, 13, 13f, 14, 444
- Daimler-Chrysler, 397
- dairy cattle, 281
- Darwin, Charles, 4
- DDG. See distiller's dried grains
- DDGS. See distiller's dried grains with solubles
- DDS. See distiller's dried solubles
- DDT, 45–46, 486
- dead zones, 155f, 156
- deaths, smoke-related, 339, 340
- deforestation, 302
- Deffeyes, Kenneth S., 62
- degree day, 166
- dehydration, 78f
- dehydrator, 115, 115f
- denaturants, 268, 270–271, 274, 327, 394  
gasoline as, 429, 500  
regulations on, 470, 500
- denatured alcohol, 13, 327, 340, 470. See also completely denatured alcohol; specially denatured alcohol
- density, ethanol v. gasoline, 374
- Department of Energy (DOE), see U.S. Department of Energy
- Department of Motor Vehicles (DMV), FFV list from, 514
- Department of Scientific and Industrial Research of New Zealand, 348
- desiccant, 226, 227
- destructive distillation, 437
- developing countries  
alcohol potential uses in, 339–341  
cassava grown in, 122  
economic benefit to, 41  
motorcycle use in, 421, 425
- dewatering, 176, 237, 263, 264  
DDGS and, 297  
equipment for, 236, 263, 264f  
stillage and, 304–305
- dextrin, 83, 95, 96f
- dextrose, 108
- diabetes, 158, 173
- diaphragm pump, 252, 252f, 254f, 255, 273f
- diarrhea, 340  
corn feed and, 144  
distiller's feeds and, 282, 283
- diesel  
alcohol fuel blended with, 450–451  
biodiesel and, 73–74  
synthetic, 14
- diesel engine(s), 333–336, 419, 449–454  
cetane improvers for, 208  
fuel injection, 451  
HCCI technology for, 335  
hybrid spark-ignited, 453–454
- use of, 449
- diesel engine conversion, 419, 449–454  
biodiesel/alcohol blend for, 450–451  
dual-injection, 451–452  
fumigation/injection approach to, 452–453, 452f, 453f  
problems in, 450  
tools for, 451, 452
- diesel fumigation kit, 452f
- diesel glow plugs, cold-starting with, 396
- Diesel, Rudolf, 14
- diester, 428
- diethyl ether, 391  
cetane improved by, 451  
cold-start system, 392–395
- diethyl nitrate, 451
- diffusion method, feedstock fermentation, 85, 86–88
- digestion. See also specific livestock  
cellulytic, 280  
ruminant, 121, 279–280
- dimethyl ether (DME), 438
- direct refluxing, 199
- Discol fuel, 16
- disease  
cancer, 30  
in cattle, 144, 316
- displacement engine(s), 416
- displacement pump, 151
- distillate, 215f
- distillation, 12, 117, 185–230. See also alcohol yield(s); distilleries; still(s); stillage  
agitation and, 251–256  
atmospheric, 187, 189, 214, 225  
automated/24-hour, 209  
azeotropic, 225–228  
batch, 195–206, 484  
batch v. continuous, 207, 209  
benzene tertiary, 226  
byproducts of, 288  
continuous, 87–88, 194, 197, 206–209, 479–481  
definition of, 185  
destructive, 437  
dump, 194  
enrichment principle in, 192, 192f, 194, 206  
extraction timing in, 204  
fractional, 139, 439  
heat sources for, 186–187, 187, 189–190, 190f, 201f, 202, 210–211  
industrial, 206–209  
manual system override in, 200–201, 203–204  
mash residue from, 42  
middle cut of, 206  
nutrients from, 277  
one complete, 191f  
pH and, 204  
phase-change energy and, 186–187  
pressure and, 187  
principles of, 192, 194, 206  
rate of, 234  
temperature control factor in, 197, 199–201  
vacuum, 134f, 209–216, 215f  
vapor pressure control factor in, 201–204  
ventilation during, 247
- distiller's dried grains (DDG), 278–279, 280, 281, 282, 292–294, 297, 298, 481  
as cattle feed, 316

methane production and, 293, 298  
 mushroom cultivation example of, 314, 314f  
 distiller's dried grains with solubles (DDGS), 32, 278  
 algae and, 293  
 corn and, 143  
 earthworms fed on, 296, 297  
 herbicidal effect of, 47–50  
 single-cell protein and, 305  
 shrimp and, 294  
 storage of, 279  
 tilapia and, 283, 290, 291, 292  
 weed experiment using, 47–50, 47f  
 wheat, 177  
 distiller's dried solubles (DDS), 278  
 yeast and, 306–307  
 distiller's feeds, 47–50, 277–286, 288, 289–298, 301. See also specific types of  
 aquaculture and, 289–294  
 cattle, 280–281  
 dogs, 283  
 earthworms and, 296–297, 314  
 feeding livestock with, 280  
 fish production and, 283, 289–294, 314  
 mushroom cultivation and, 286–289, 314, 314f  
 pigs and, 282–283  
 poultry and, 283  
 single-cell protein and, 305  
 sheep and, 281–282  
 shrimp and, 294–295  
 small plant operations in, 278–279, 292–294  
 types of, 278–279  
 wheat and, 177, 280  
 yeast and, 306–307  
 distiller's solubles (DS), 278, 284, 284f, 293, 297, 298, 304, 459  
 methane conversion of, 316  
 mushroom/fish production using, 312, 313  
 surplus, 320  
 distiller's yeast, 107, 107f, 135  
 distillery, 9. See also micro-plant; small plant; still(s); tanks  
 automated, 201, 209, 479–481, 486–489, 487f  
 batch, 217, 484–486  
 continuous, 87–88, 479–481, 486–489, 487f  
 cooling issues in, 216, 220  
 examples of, 479–492  
 experimental, 469  
 fuel-oil tank, 217f  
 functions of, 191  
 heat pumps and, 211–213, 218–221, 312  
 hot-oil furnace, 185f  
 layout of, 234f, 237–239  
 legal considerations for, 469–471  
 reboilers for, 194, 217–218  
 size of, 191, 217, 469  
 tank selection for, 241–246  
 urban/suburban, 80–82  
 vacuum, 215f, 481, 483f, 484f, 485f  
 wood-fired, 201f, 221–225, 221f  
 distributors  
     electronic system, 404–405  
     history of, 12, 399–400, 400f  
         mechanical system, 401–404  
 D-Jetronic fuel injection system, 381, 382  
 DME See dimethyl ether

DMV See Department of Motor Vehicles  
 DNA, genetic engineering theory of, 281  
 Doc Sweeney, 1  
 Dodge, 444  
 DOE, See U.S. Department of Energy  
 Doering III, Otto, 521–522  
 dogs, distiller's feeds and, 283  
 Dometic AB (Sweden), 340, 341  
 dosage  
     definition of, 85  
     enzyme, 94–95  
     sugar, 105–108  
 doubler still, 192–193, 192f  
 downcomer, 193–195  
 downdraft, 139, 422  
 downspeeding, 336  
 drill  
     precision seed, 173  
     press, 365  
 drill bits, equivalent sizes for, 367f  
 drilling  
     accelerator pump jets, 369, 370  
     metering jet, 365–366  
     motorcycle hose/clamp, 423  
 drip irrigation, 303, 303f, 317  
 drive/timing belt sheaves, agitation and  
     high-torque, 248  
 drum dryer, 234, 265  
 drum method, mash drying, 265  
 dry gas, 356  
 drying  
     alcohol, 226–227, 227f, 236, 237  
     distiller's feed, 279  
     mash, 261–265, 263f, 266f  
     WDG, 279  
 dry-milling, 47, 137, 279f  
 DS. See distiller's solubles  
 dual-fuel capability, 386, 387, 435–436, 529  
     carburetion conversion, 369, 373, 430f  
     computer ECU with, 390  
     device for, 388  
     ignition timing and, 404, 405  
     spark plug adjustments for, 412  
     superchargers and, 418  
 dual-injection diesel engine, conversion of, 451–452  
 Dukes, Jeffrey, 30  
 dump, distillation, 194  
 duty cycle meter, 369f, 384  
 dwell meter, 369f, 384  
 dynamometer, 453  
 E-10 engines, 327  
 E-85 fuel, 70, 527  
     auto/oil company bargains and, 430–431  
     blend formula for, 70, 325–331, 360  
     cold-starting and, 392, 394  
     costs/credits for, 464f  
     emissions reduction of, 329  
     hybrid vehicles on, 328  
     legal definition of, 468  
     locating, 513  
     MegaOilron and, 463  
     RVP of, 360  
     Sweden, 70  
     unmodified vehicles using, 325–331  
 E-95 fuel, 426  
 E-98 fuel, 350, 468, 527  
 E-100 fuel, 357, 496  
     FFVs and, 500  
     mileage and, 432  
     tax credit proposal for, 496, 497

Earth Island Institute, 52  
 earthworms, 295–297, 314  
 ecology  
     DDT and, 45–46, 486  
     dead zones and, 155f, 156  
     ethanol and, 29–31  
     fertilizer and, 45, 49–50, 79, 130, 170–171  
     permaculture and, 40, 58  
 economic considerations  
     alcohol fuel production, 458–465  
     expenses/credits overview of, 460–461f  
     micro-plant example of, 458–459, 460–461f  
 economy. See also community-supported energy  
     Brazil's, ethanol and, 73  
     CAFE, 12, 429–431  
     developing countries, 41  
     hydrogen, 63, 64, 64f  
 ECU. See electronic control unit  
 Edey, Anna, 317  
 EFI. See electronic fuel injection  
 EGR. See exhaust gas recirculation  
 EGT. See exhaust gas temperature  
 EIA. See Energy Information Administration  
 Eisenia foetida, 295  
 El Salvador, 289  
 electric fuel pump, cold-start systems, 395  
 electric motor agitator, 249, 254  
 electricity, 197. See also cogeneration  
     bagasse used for, 25, 25f, 71–72  
     coal for, 57, 442  
     fuel cells and, 63, 64  
     fuel/feed plant, 25, 25f, 71–72, 129, 233, 286, 318, 442–443  
     hybrid vehicle, 442  
     hydrogen conversion to, 64–65  
     hydropower, 72  
     industrial rates for, 485  
     meters, public utility, 445, 485  
     methane, 318  
     natural gas conversion to, 190  
     storage of cogenerator, 444, 445  
 Electrojector, 378  
 electronic carburetors, 374–375  
 electronic control unit (ECU), 328, 378, 528, 529  
     aftermarket/programmable, 389–390, 529  
     exhaust temperature comparison and, 344  
 electronic distributors, timing adjustments for, 404–405  
 electronic fuel injection (EFI), 329  
     first, 378  
     types of, 381  
 electronic timing advance, 404, 404f, 530  
 embodied energy, 64  
 Embraer (Brazil), 337  
 Emerson, Ralph Waldo, 142  
 emissions  
     advance ignition systems and, 405  
     aldehyde, 348  
     butanol, 439  
     carbon monoxide, 35, 329, 333f, 347, 366  
     CO<sub>2</sub>, 35, 54, 347  
     coal, 57–58  
     control devices, 351  
     diesel, 40, 452  
     E-85, 329  
     engine conversion and, 366  
     evaporative, 34–35, 348

fuel injection conversion and, 384  
gasoline v. alcohol fuel, 35, 329, 347–351  
methane hydrate, 62–63  
methanol, 438  
myths about, 347–351  
nitrogen, 52  
NO<sub>x</sub>, 35, 329, 330f, 331, 347, 410  
particulate, 348  
permeation, 350  
reformulated gas, 330f  
sulfur, 52  
unmodified vehicle comparison of, 330f  
vaporization and, 333f  
water vapor, 35

employment  
alcohol production, 34, 318, 320, 340, 513  
coffee production and, 142

emulsion  
chive concentrate, 291–292  
fish, 292

energy, 32, 343, 513. *See also* cogeneration; community-supported energy  
boiling point and, 210–214  
CO<sub>2</sub>, 300  
coal, 57–58  
community-supported (CSE), 459, 466  
content v. efficiency, 351–353, 352f  
continuous distillation and, 208  
conversion of, 190  
embodied, 64  
EROEI and, 24–37, 53, 54, 156, 519–524  
future of, 51–66  
gasoline losses of, 344f  
heat transfer and, 185–188, 189, 190–191  
independence and, 477  
large fuel/feed plant use of, 278  
loss of, 190  
mechanical, 64  
microwave, 186  
natural gas, 52–53  
nuclear power, 59–61, 63–64, 221, 247, 486  
renewable energy credits and, 462–463  
scam on, 72  
solar, 21, 83, 156, 175, 187, 500  
starch as, 83–84  
stillage, 298  
storage of, 445  
energy balance, research on, 25, 519–524  
energy corporations  
research approved/funded by, 343, 347, 348  
energy crop(s), 27–29, 42, 119–180, 510  
cellulose, 28–29, 512  
corn as, 27, 29, 143–144  
feedstock as, 307–308  
growth conditions for, 119  
land for, 119, 128  
marine algae as potential, 156–157  
overview of, 119–120  
potential, 119–180, 156–157  
Energy Information Administration (EIA), 59  
Energy Research Advisory Board, 520  
energy returned on energy invested (EROEI)  
myths about alcohol, 25–26  
in Pimentel studies, 519–524  
tar sands, 53, 54  
energy revolution, 503  
engine(s). *See also* engine conversion  
adding diethyl ether to, 392–395  
air-cooled, 408–409, 421  
aircraft, 336–339

airflow engine tuner for, 387  
alcohol-dedicated, 333–336, 350  
carburetor, 363–364, 364f  
chainsaw, 425, 426–427  
cogeneration systems and, 443  
cold-starting, 337–338, 337f, 391–397  
compression, 415–419  
cooling fans in, 345–346  
cycle of, 346f  
design of, 359, 378  
diesel, 333–336, 419  
diesel v. gasoline, 449  
displacement, 416  
distributors/spark plugs history of, 399–400  
E-10, 327  
FFV, 431–432  
four-stroke, 428  
fuel-injection, 327–328, 332f, 363–364, 395, 397  
GX, 435  
GX NGV, 435  
ICE, 11, 63  
lubrication of, 425, 426–427, 428  
motorcycle, 421–423  
solar-hydrogen-fuel-cell, 64–66  
surplus heat from, 442  
utility, 423–425, 424, 424f  
vacuum, 332  
vaporized alcohol, 331f, 332–333, 335, 418, 421f  
variable-compression, 433–435  
waste heat and, 442

engine control unit (ECU), 379, 431, 432, 434  
fooling, 386

engine conversion, 363–375, 400–405, 407–413. *See also* carburetor conversion; dual-fuel capability  
acceleration example in, 529  
aircraft, 337–338, 337f  
basis of, 377–379  
blowers and, 418–419  
Bosch systems and, 377, 379  
castor oil, 452  
choke and, 411  
cold-start systems and, 391–397, 418, 527f  
compression increase for, 415–419  
diesel, 419, 449–454  
experiences with, 527–532  
FFV modifications and, 407, 432  
fuel injection and, 379, 381–390  
fuel lines and, 355  
fuel preheating and, 407–410, 408f  
gasket adjustments in, 412–413  
gasoline usage after, 369, 373, 404, 405, 412, 418  
ignition timing adjustments for, 399–405, 401f, 402f, 530  
intake air heating, 410–411  
legalities of, 467–469  
low-proof alcohol and, 353  
manifold adjustments in, 413  
motorcycle, 421–423  
oxygen sensors and, 356  
small, 421–428  
spark plugs and, 411–412  
two-stroke, 425–428  
utility, 423–425

engineering information, 540–543f  
Engle, Barry, 74  
Engler, Allan, 338

enrichment  
air/fuel ratio, 339, 365, 367, 368–369, 383, 410, 424, 529  
CO<sub>2</sub> plants and, 300–301, 302–303, 304, 311f  
distillation principle of, 192, 192f, 194, 206

ensiling, 124, 279

environment. *See also* ecology; pollution  
acid rain and, 54, 57–58  
alcohol leakage and, 268  
coffee production as degrading, 141  
deforestation of, 302  
ethanol v. gasoline influence on, 344  
methane hydrates and, 61–63

Environmental Protection Agency (EPA)  
alcohol-fueled vehicle prohibition by, 467  
gasoline v. ethanol study of, 347  
methanol v. ethanol study of, 334–335

enzymatic hydrolysis, 132, 133–137

enzymes, 83, 84  
barley malt source of, 113–114  
cellulase, 92, 133  
dosage of, 94–95  
feedstock fermentation and, 90, 92, 93–95, 104, 113–114, 115, 133, 139–140  
fungal/bacterial, 113  
GMO, 134  
temperature and, 94

EPA. *See* Environmental Protection Agency

equal-feeding manifold, 407f

equilibrium  
distillation and, 208, 220  
fermentation and, 87  
fuel preheating and, 408

equipment. *See also* agitators; pumps; tanks  
alcohol-drying, 226, 237  
azeotropic distillation, 227  
cleaning of, 257  
composting, 286  
control coil construction, 205  
dehydrator, 115, 115f  
diffusion method, 87  
embedded energy of farm, 521f, 522–524  
farm, 9f, 13f, 486, 521f, 522–524  
fruit shredding, 484  
fuel/feed plants, 239–246, 481–482  
mash dewatering, 236, 263  
mash drying, 261, 262, 263, 263f, 264–265, 266f  
methane production, 267  
micro-plant, 231–233, 239–241, 264, 312  
preprocessing, 239–241  
safety, 115–117  
small plant, 234–237, 239–241  
starch fermentation method, 97, 99, 103, 109, 109f

sugar fermentation method, 85, 85f, 86, 86f

sugar testing, 90, 91  
whole-pulp fermentation, 88, 94

EROEI. *See* energy returned on energy invested

esters, fusel oil, 354

estrogenic effects, 30

estrogenic pesticides, 30

ethanol, 23. *See also* alcohol fuel; ethanol v. gasoline; specific blends  
ABE made from, 439  
aviation use of, 337–338  
Brazil economy and, 73

cellulose source of, 129–138  
 diesel mixed with, 450  
 ecology and, 29–31  
 EROEI for, 25–26, 53, 156, 519–524  
 heating, 409  
 hydrogen reforming of, 65  
 incentive programs, regulations for, 463–464  
 MegaOilron purchase of, 464  
 methanol v., 334–335  
 monoculture studies of, 31  
 myths about, 344–360  
 neat, research data for, 343  
 octane in, 337, 435  
 oil processing and, 111  
 as solar hydrogen source, 65–66  
 turbines and, 443  
 unmodified vehicle performance of, 326, 328–331  
 vaporized v. liquid, 333f  
 ethanol v. gasoline, 35, 329, 374, 408  
 air/fuel ratio for, 364, 367, 368–369, 388, 400, 410  
 ratio in, 388  
 auto ignition point of, 358  
 blends and, 356–357  
 carburetor corrosion of, 354, 354f  
 carcinogens from, 348  
 cold-starting in, 360  
 combustion of, 343, 344–347  
 corrosion from, 353–356  
 data availability for, 343–344  
 energy loss and, 344f  
 engine performance myths about, 344–360  
 EPA study on, 347  
 lubrication qualities of, 344, 356  
 mileage for, 351–353  
 phase separation comparison of, 356–357, 357f  
 properties comparison for, 345f  
 research on, 343–360  
 RVP of, 350  
 ethanol v. gasoline v. methanol, properties comparison for, 345f  
 ether. See also diethyl ether  
 denaturing alcohol with, 394  
 fires from, 394  
 fuel mixed with, 427  
 ether bottles, 394  
 ethyl carbamate, 104  
 ethylene glycol nitrate, 451  
 Europe  
     alcohol fuel promotion in, 16  
     Discol fuel of, 16  
 European Union, 70  
 Evans, Lanto, 223  
 evaporation  
     crankcase oil, 428f  
     liquid from solubles, 305  
     water, 48, 71, 278  
 evaporative emissions, 34–35, 348, 350  
     permeation v., 350  
 evaporative manifold cooling, 370  
 Everclear, 478  
 exhaust  
     hydrocarbons in, 347, 350  
     pollution from, 347, 425  
     temperature of, 344  
         water content in alcohol, 356  
 exhaust gas analyzer, 339, 366, 368  
 exhaust gas recirculation (EGR), 334, 348,

418  
 exhaust gas temperature (EGT), ethanol v. gasoline, 344  
 exhaust gas temperature (EGT) gauge, 366, 367, 367f  
 exhaust pipe, 346f  
     carbonization of, 421  
 expansion valve, 218, 219  
 exploitation, of war/terrorism threat, MegaOilron's, 19–20, 32  
 explosions  
     butane, 216  
     liquefied natural gas, 57  
 ExxonMobil, 438  
 FAA (Federal Aviation Administration), 337, 338  
 Fahrenheit–Celsius conversion, 533f  
 fans, belt-driven v. cooling, 345–346  
 farm equipment  
     embedded energy of, 521f, 522–524  
     tractor, 9f, 13f, 486, 519f, 522–524  
 farmer cooperatives, Germany's, 11, 14  
 farmers  
     co-op v. conventional, 504  
     CSA movement and, 512  
     feedstock selection for, 77–79  
         WW I and, 15–16  
 farmers' union, 14  
 farming, Brazil, 70–71  
 farmland  
     organic matter %, 39  
     U.S., 27  
 Farruggio, Matt, 479  
 fatty acids, yeast and, 120  
 fear, 327  
 Federal Aviation Administration (FAA), 337, 338  
 federal tax benefits, 462–463  
 federal tax credits, 2, 496, 497  
     micro-plant, 497  
 feed. See animal feed  
 feed chute, 266f  
 feedback system, 404–405  
 feeding, livestock, 279–283, 291, 316  
 feedstock(s), 13, 498  
     alcohol fuel production, 27, 27f, 119–180, 486  
     animal feed, 121, 122, 138, 160, 163  
     buffalo gourd, 120–122  
     cassava, 84, 96–102, 101f, 113, 113f, 122–125, 124f, 288  
     castor beans, 125–126  
     cattails, 28, 126–129, 126f  
     chestnuts, 138  
     coffee, 139–142  
     comfrey, 142–143  
     contracting for, 510–511  
     diversity of, 498, 512  
     energy from, 307–308  
     expenses/credits for selected, 460–461f  
     fodder beets, 144–147  
     forage plants, 147  
     fruit, 80, 86, 139, 211, 307, 484  
     Jerusalem artichokes, 147–152, 148f  
     lichens, 152–153  
     liquid, 486  
     marine algae, 153–157  
     mesquite, 157–158  
     molasses, 159–160, 486  
     palm, 160–163  
     pimelon (wild watermelon), 163  
     prickly pear, 164–165  
     sherry, 211  
     storage of, 77–78, 176  
     sugar beets, 165–167  
     sugarcane, 166–171, 211  
     sweet potatoes, 171–172  
     sweet sorghum, 172–175  
     tropical fruits, 175–176  
     turnips, 180  
     various, 119–180  
     viscosity for sample, 544f  
     wheat, 177–178  
     whey, 178–180  
     yield by, 78, 78f, 79, 79f  
 feedstock elevator, 236f  
 feedstock fermentation, 83–117. See also byproduct(s); equipment; feedstock(s); yield; specific feedstocks  
     advanced cooking techniques for, 112–115  
     agitation in, 94, 99, 101, 105, 249–251  
     batch method of, 96–102, 235  
     contamination and, 109–111  
     diffusion method, 86–87  
     enzymes and, 90, 92, 93–95, 104, 113–114, 115, 133, 139–140  
     equipment for, 85, 85f, 86, 87, 88, 90, 91, 94, 97, 99, 103, 109, 110, 115, 115f  
     juicing approach to, 85–87  
     starch method, 95–102  
     sugar method, 85–95  
     sugar testing in, 90–91, 91f  
     terminology for, 84–85  
     whole-pulp, 87–88  
     yeast and, 84, 100, 102–111  
 feedstock selection, 77–82  
     byproducts and, 77, 79  
     farmers', 77–79  
     fuel/feed plant design and, 233  
     urban/suburban distillers', 80–82  
 feedstock trials, 13  
 feed-to-flesh ratio, 289  
     earthworms, 288, 295, 296  
 fermentable sugars, 89, 133  
 fermentables, 78, 111  
 fermentation, 9. See also feedstock  
     fermentation; specific feedstocks  
     agitation and, 249–251, 481  
     anaerobic/bacterial, 297  
     butanol, 439, 440  
     C5 sugars and, 134, 135, 307  
     C6 sugars and, 133, 137–138  
     cellulose, 307  
     CO<sub>2</sub> from, 304  
     cooking combined with, 458  
     definition of, 84  
     nutrients and, 104, 104f  
     nutrition and, 104–105  
     pitching yeast in, 108–109  
     plant scale and, 96  
     separating solids before, 481  
     stages of, 105, 105f  
     starch method, 95–102, 109f, 111–115  
     sugar method, 85–95, 91f  
     sugar testing in, 90–91, 91f  
     yield calculation in, 111–113  
 fermentation lock, 105, 107, 107f, 110f, 232, 237  
 fermentation lock valve, 232f  
 fermenter, 86, 234–237, 241, 242, 244, 485, 485f  
     CO<sub>2</sub> from, 279, 292, 306, 481

fermentation tanks, 42, 110, 110f, 244  
as carbon dioxide source, 42  
fertilization, 169  
fertilizer, 30  
biological, 170–171  
byproducts as, 11, 79, 286, 321  
cellulose and, 28  
chemical, 45, 130  
compost tea, 141, 142, 286, 321  
corn and, 143  
feedstock selection and, 79  
fish water, 317  
marine algae, 156–157  
mash byproducts used for, 79  
permaculture and, 40  
shrimp shell, 294  
soil microlife as, 49–50  
stillage in, 283–284, 298  
vinasse, 169, 169f

FFVs. See flexible-fuel vehicles

field capacity, 146

field trial, Shell Oil's HE 100, 356

Fifth International Alcohol Fuel Technology Symposium, 304, 356

filibustering, 477

filling port, vacuum still, 215f

film strength, 415, 428

filtering, fuel, 273

fin tubing, 257, 262

fip (female internal pipe thread), 245

fire department regulations, 476

firebox, 198f  
brick, 490f  
design of, 221–223, 221f, 223f, 225

fires, 274  
alcohol v. gasoline, 343f

fire-tubes, 226–227, 262

firewood  
coppiced woodlots for, 318  
growing/using, 318

Fischer, Tom, 434

fish emulsion, 292, 315

fish production, 289  
algae/marine algae in, 292–293, 315  
biofilter for, 291  
distiller's feeds for, 283, 289–294, 314  
space for, 315  
water from, 291, 316–317, 317, 461

Fitch, Bob, 69

five-carbon sugars (C5 sugars), 133–136, 138, 307, 440

flame front, 352, 359f, 415

flame propagation, 335, 347, 359, 403

flash heater, 484

flashpoint, 268  
alcohol/water blends, 269f  
gasoline, 392  
gasoline, methanol and ethanol, 345f  
natural gas condensates, 392  
synthetic oil v. petroleum, 415

flatstock, 224, 232f

flexible-fuel vehicles (FFVs), 429–435  
alcohol fuel proportion/% for, 431, 433  
Brazil, 74, 226, 432–433, 500  
cold-starting, 360  
DMV listing of, 514  
engine conversion of, 407–413  
engines, 431–432  
first, 429, 431, 432  
history of, 429–431  
ideal, 360  
incentives for, 499

invisibility of, 431  
mileage and, 432  
modifications to, 432  
U.S. v. Brazilian, 433

flighting, 250f

flinty starch, 95, 97

float bowl, 364, 365f, 373f, 374

float needles, utility engine carburetor, 425

float switch, 229

float valve, 364f, 373

flow-control valve, 199  
column still, 199, 200f, 229  
coolant, 200f

flowers, CO<sub>2</sub> levels for, 301

flue gases, 189, 222, 304

fluorocarbon elastomer, 355

fluoroelastomer. See fluorocarbon elastomer

foam insulation, 222–223

fodder beets, 119f, 144–147  
byproduct, 146  
planting, 145

Fodge Engineering, 527

fogger, 229, 231

FOIL (Foreign Oil Independence League), 325

food  
plant, 43–45  
SCP sources of, 304

food processing plants, 492

food shortage myth, 31–32

fooler technologies, fuel injection  
conversion using, 385, 386–389

foot-candles, 41f

forage plants, 147

Ford, 431  
Ford Brasil, 74, 429  
Ford, Henry, 16, 79, 278, 379, 444, 446  
Rockefeller and, 11–14

Ford Pinto, 417

Ford Ranger, 432

Foreign Oil Independence League (FOIL), 325

foreshot, 190, 204, 206, 217

formic acid, 438

fossil fuels, 15  
coal, 57–58  
energy return on, 25–26  
projected supply/consumption, 53, 53f

fossil fuel dependency, permaculture  
solution to, 39–50, 298

Four Corners coal strip mine, 58f

fractional still/distillation, 139, 439

France, 70

Franklin, Benjamin, 366

freon, 218  
heat source, 219–220  
heat storage and, 217

frequency valve, 383

friction loss, valves and fittings, 543f

fructose, 100

fruit, 211, 307  
citrus, 139  
shredding, 484  
starch v., 80  
tropical, 171–176

fruit pulp, as livestock feed, 86

fuel  
adding, cold-start systems, 392–396  
alcohol-only, 333–336  
atomization of, 408, 409, 410  
butanol, 439  
chemicals entering, distillation and, 204

climate, 225

cold-start devices and, 527

compatibility, water/ethanol/gasoline, 357f

consumption, 36–37

cooking, 339–340

ether mixed with, 427

filtering, 273

fossil, 25–26, 39–50, 53, 53f, 57–58

heaters, 408–409, 408f

hydrogen, 65, 65f

land and, 157

methanol, 344, 345f, 431, 438–439

preheating, 407–410, 408f

pressure, 383, 385–386, 530

renewable, 2, 20–21, 463–464, 495–505

reservoir, cold-starting and, 423

RFS regulation for, 20, 463, 499

zoning regulations for, 505–506

fuel blends. See blend(s)

fuel cells, 63f, 514. See also solar-hydrogen-fuel-cell engine  
electricity and, 63, 64  
ethanol, 65–66  
reforming and, 431

fuel co-ops, 491–492  
byproducts and, 510–512  
cogeneration, 447  
CSA model for, 503–505  
CSE, 34, 505–513  
integrated production in, 510–512  
joining with other, 509–510  
legal structures for, 466–467  
organizational structure of, 507–509  
physical site for, 505–507  
rebates for, 464

fuel delivery  
air tuners for increasing, 387  
basic fuel injection system for, 381f  
engine design, gasoline and, 378  
recalibration of, 384

fuel efficiency, 422, 432. See also ethanol v. gasoline  
energy work and, 351–353, 352f  
flame propagation and, 359

fuel/feed plant, designing, 231–274

fuel heating, 408–409, 408f, 531f  
motorcycles and, 423, 424  
utility engine, 424

fuel injection  
alcohol fuel and, general issues for, 379  
basic system of, 381f  
carburetors and, 363–364  
cold-start systems and, 395, 397  
computerized, 327–328, 389–390  
damage to, 379  
delivery issues in design of, 378  
diesel, alcohol in, 451  
first electronic, 378  
history of, 377–379  
oxygen sensor role in, 379–380  
preheating and, 409–410  
proof and, 379  
timing, 431–432, 530  
vaporization and, 332f, 333

fuel injection conversion, 379, 381–390  
approach overview for, 385  
dual-fuel capability and, 386, 387, 388  
fooler technologies for, 386–389  
fuel delivery and, 383, 384  
fuel pressure regulator adjustments in, 382–383

newer systems, 385–390  
older systems, 381–385  
pressure increase approach to, 385–386  
fuel injector, in distillery, 229  
fuel line heaters, 396–397  
fuel lines, 423  
alcohol-proof, 355  
corrosion and, 354  
increasing pressure in, 382  
urethane, 355  
fuel oil burners, 196–197, 201, 213, 446  
fuel oil tank  
as alcohol dispenser, 510  
distillery, 217f  
for storing alcohol, 272  
fuel pressure, 530  
CIS types of, 383  
increasing, 385–386  
fuel pressure regulator, 382–383, 383f  
FFV, 432  
fuel pump(s)  
alcohol-safe, 354, 355  
electric, cold-start systems and, 395  
manual, 273f  
mechanical, 395–396, 396f  
oil, household heating and, 446  
utility engine, 424  
fuel pump intake filter, 355f  
fuel rails, 528  
fuel tanks, 268–269, 268f, 269f, 271  
fuel/feed plants, 55. See also distilleries;  
micro-plant; small plant; tanks  
application procedure for, 471, 475  
automated/24 hour, 201, 209, 479–481,  
486–489, 487f  
butanol production in, 440  
cogeneration and, 21, 71–73  
cost of building, 33, 51  
CSE style, 34, 459, 466, 503  
designing, 231–274, 440, 492  
diversity of, 231  
economic considerations for, 458–465,  
460–461f, 466, 497  
electricity for, 25, 25f, 71–72, 129, 233,  
286, 318, 442–443  
energy return on, 25–26  
equipment for, 239–246, 481–482  
examples of individual, 479–492  
grain-based, 235  
large scale, 34, 96, 278, 284, 306, 458  
layout of, 234f, 237–239  
legal considerations for, 465–478  
maintenance cost estimates for, 460  
micro-plant design of, 231–233, 311–321,  
492  
modular, 492  
neighbors and, 475–476  
nonprofit set-up for, 466  
permits for, 469–471, 472–474f, 475  
plumbing for, 236, 253, 254–256  
power for operating, 72, 254, 265–266,  
278, 286, 298  
single-tank, 232–233  
site for, 238–239, 476–478  
small v. large, 34, 96  
small-plant design for, 234–237, 440  
surplus heat storage and, 188–190  
tax benefits from, 33, 461–465  
zoning issues for, 476  
Fuller, R. Buckminster, 23, 28, 63, 66  
fumigation, 452–453, 452f, 453f  
funding, research, 343, 520

fungal enzymes, bacterial combined with,  
113  
fungi. See also single-cell protein  
chemical fertilizers killing, 130  
compost and, 284–285  
plant feeding and, 43–44, 45  
furfural, 133  
fusel oil, 194, 206, 208, 354  
future  
dedicated alcohol engine, 333–336  
CSEs and, 512–513  
energy, 51–66  
Future Farmers of America, 514  
futures market, oil companies and, 501  
gallage  
continuous distillation and, 197  
tank, round vertical, 541f  
garlic, 80, 500  
gas pump hydrometer, 69f  
gas stations, U.S. number of, 496  
gas, synthetic unleaded, methanol and, 438  
gaskets, 245, 271, 354  
modification to, 412–413  
gasohol, 354, 355  
fires and, 274  
gasoline. See also emissions; ethanol v.  
gasoline; specific blends  
additives in, 350, 356, 357–358, 360  
air/fuel ratio for, 364, 379–380, 380f  
alcohol blended with, 70  
alcohol fuel mixed with, 225–226, 375,  
431  
alternating between alcohol fuel and,  
369, 373, 386, 404, 405, 412, 418  
average latent heat of, 344  
aviation, 336–337  
boiling point of chemicals in, 332  
carcinogens in, 357  
cold-start systems using, 392, 396f  
denaturant use of, 429, 500  
diesel v., 449  
energy losses of, 344f  
engine design influenced by, 378  
flashpoint of, 268  
fuel delivery for, 378  
history of, 11, 12, 15  
lead in, 355, 357, 358  
market for, 219  
methanol v., 431  
octane in reformulated, 426  
oil contaminated by, 373  
oil profitability v., 350  
preheating, 408  
price per gallon, 33, 432  
“regular,” toxicity of today’s, 357–358  
stoichiometric ratio of, 379, 380f  
surplus, 267  
switching back to, 373, 386, 404, 418  
toxic contents of, 350  
toxic waste and, 12  
gasoline v. ethanol. See ethanol v. gasoline  
gas-to-liquid heat transfer, 224  
gate valve, 200  
gelatinization, 95, 97, 97f, 101f, 112–113, 248  
General Motors  
FFVs, 429, 431  
fossil fuel projection, 53, 53f  
generators  
alcohol from, 444  
turbine-driven, 443  
genetic engineering, DNA theory of, 281

genetically modified organisms (GMOs)  
bacteria, 135, 140  
contamination by, 136  
enzymes, 134  
herbicides and, 30  
yeast and, 134, 136, 137, 307  
*Geotrichum candidum*, 304–305  
Germany, 17  
farmer cooperatives in, 11, 14  
I.G. Farben Company of, 18  
GFF. See grain fermentation factors  
Gillette, Guy, 18  
global warming, 21, 62–63, 197, 413  
CO<sub>2</sub> and, 299, 302  
marine algae cultivation and, 35–36, 156,  
302  
ocean expansion caused by, 186  
glow plug, 334, 396, 418, 454  
glucoamylase, 92, 100  
pH requirement of, 100  
glucose, 40, 83  
cellulose containing, 129  
glycerin waste, 440  
GMOs. See genetically modified organisms  
González, Neris, 289  
Goodman, Paul, 484–486, 485f  
Goodman, W.L., 485, 486  
grain. See also distiller’s dried grains and  
solubles  
calculating starch in, 112  
fuel/feed plants based on, 235  
grain dryer, 263f, 264–265  
grain fermentation factors (GFF), 278  
grain grinders, 239–240  
grain mash, 284f  
Grange (farmers’ union), 14  
grass clippings, 29, 131  
Grassley, Charles, 137  
gravity tank, 270  
the Great Depression, 15–17  
green revolution, 39–40  
greenhouse effect, 56, 499  
greenhouse gas, 31, 36–37, 53  
Kyoto treaty and, 499  
methane hydrate, 62  
most dangerous, 35  
nuclear power plant, 61  
greenhouses  
ADM model for efficient, 300, 301, 311f  
CO<sub>2</sub> enrichment in, 300, 301, 302, 304,  
311f  
CO<sub>2</sub> use by, 300–302, 312  
fuel/feed plant design and, 235, 237  
heat from, 301–302  
grid, 25, 63, 72, 298–299  
connecting to, 445–446  
gristmill, 96, 240  
Gross Universal Cash Heist (G.R.U.N.C.H.), 23  
grounding, 272  
groundwater, alcohol storage and, 268  
G.R.U.N.C.H. See Gross Universal Cash Heist  
Hall, Jim, 486–489, 486f  
Halliburton, 56, 496  
Hamilton, Alexander, 10  
hammermill, 96, 233, 239f, 240  
Hannah, Daryl, 363  
hard plumbing, 236, 255, 256, 257f  
hardened munitions, 60  
hardpan, 142, 145  
Harken Bahrain Oil Co., 496  
Harken Energy, 497

- Harkin, Tom, 355  
 Harley motorcycles, 426  
 harmonic balancer, 401  
 hatches, tank, 87, 232f, 233, 233f, 242–243, 244, 244f  
 hazelnuts, 138–139  
 HC. See hydrocarbons  
 HCCI See homogeneous charge compression ignition  
 HE-100, field trials on, 356  
 heat. See also heat source(s); process heat; waste heat  
     continuous distillation and, 208  
     equilibrium, 220  
     greenhouse, 301  
     liquid alcohol, 210  
     radiant, 307  
     refrigerant, 212, 213, 215  
     temperature and, 186  
 heat exchange, 199  
     energy/energy loss in, 185–188, 189, 190–191  
     gas-to-liquid, 224  
     motorcycle conversion and, 422  
     rate of, 187–188  
     surplus heat storage and, 188–190  
 heat exchangers, 99, 256, 257–261, 307  
     CO<sub>2</sub>/air-to-air, 302  
     counterflow, 233, 258–259, 261f, 424f, 425  
     external, 99, 103, 104, 233  
     fuel-to-fuel, 409  
     heat recovery and, 257–261  
     immersion coil, 207, 258, 259  
     radiators as, 187  
     reboilers as, 217  
     shell and tube, 333  
     spent mash transfer using, 260, 261  
     tube-in-tube, 260f  
     types of, 258  
     vaporizers as, 333  
 heat pump refrigerator condenser, 215  
 heat pumps, 211–213, 218–221, 312  
     engine conversion and, 423–425  
 heat recovery, cogeneration system for, 442–446  
 heat source(s). See also waste heat  
     batch v. continuous still, 207  
     biofuel, 202  
     freon gas, 219–220  
     heat pumps, 211–213, 218–221  
     liquid alcohol, 210–211  
     methane, 316  
     oil-based, 189–190, 189f, 446  
     safety and, 218  
     solar energy as, 187  
     steam, 186–187, 189  
     wood, 190, 201f, 202, 221–225, 490f  
 heat surplus. See waste heat  
 heat tanks/batteries, 188–190, 444  
 heaters, fuel, 408–409, 408f  
 heating coil, 159, 189–190  
 heating value, 30  
     gasoline, ethanol and methanol, 345f  
     methanol, 338–339  
     measurement using, as misleading, 351–353  
 heavy metals, 35  
 hectare, 41  
 height to diameter ratio  
     packed column still, 196–197, 229–230  
     perforated plate still, 207  
 Heintz, Kent, 481–484, 482f  
 Heintz, Thurly, 396, 481–484, 482f  
 Helfrich, Dan, 291, 294  
 hemp, 133  
 Henry Ford Museum, 12–14  
 Henry Ford tractor, 13f  
 herbicide(s), 45  
     biological v. chemical, 46–48  
     CGM as, 47  
     corn as its own, 46–47  
     DDGS as, 47–50  
     GMOs and, 30  
     insecticides and, 131, 170–171  
     protest/petition anecdote and, 493  
 high wine, 204  
 history. See also alcohol history  
     biodiesel, 14  
     distributors/spark plugs, 399–400, 400f  
     FFVs, 429–431, 432  
     fuel injection, 377–379  
     vaporization and, 332  
 Ho, Nancy, 132f, 135  
 holding pen, 238–239  
 holding ponds, 53  
 holding tanks, preheated mash, 260  
 homogeneous charge compression ignition (HCCI), 335  
 hoses, 271  
     breakaway fitting for, 269  
     PSI pressure loss for smooth bore rubber, 541f  
 hot water  
     engine's surplus, 442  
     holding tanks and, 260  
     household, 442  
     primary co-product economics and, 459  
     storage, 307  
     surplus, 262–263, 266, 292–293, 307, 317–318  
 hot-oil furnace distillery, 185f, 189f  
 household  
     air conditioning for, 445  
     alcohol heating for, 446  
     cogeneration for, 442, 443, 444, 446–448  
     hot water, 442  
 Hull, Dave, 127  
 humus, 49  
 Husqvarna saw, 426–427  
 hybrid vehicles  
     diesel spark-ignited, 453–454  
     E-85 for, 328  
     electricity from, 442  
 hydraulic motor, 248  
 hydrocarbons (HC), 35, 329  
     aromatic, 350  
     chlorinated, 30  
     measurement issues for, 347  
 hydrogen  
     fuel, 65, 65f  
     reforming and, 65, 431  
     sulfide, 266–267  
 hydrogen economy, 63, 64, 64f  
 hydrogen power, 64–65, 72  
     nuclear and, 63–64  
 hydrolysis, 96, 98  
     acid, 132–133, 134, 136, 137  
     enzymatic, 133–137  
     laminarin, 155  
 hydrometer sump, 203f, 229  
 ICE. See internal combustion engine  
 ice blocks, 447  
 idle circuit, engine conversion and, 368–369  
 idle mixture needle, 369f  
 I.G. Farben Company, 18  
 ignition  
     advance timing, 404, 404f, 417, 418, 530  
     aftermarket systems for, 404–405  
     auto-ignition point and, 358  
     diesel/compression, 450  
     distributors and, 399, 400–405  
     ECU and, 431, 432  
     electronic, 404–405  
     engine conversion adjustments to, 399–405, 401f, 402f, 530  
     feedback systems for, 404–405  
     FFV modifications to, 432  
     mechanical, 401–404  
     spark, 333–334, 411–412, 453–454  
     vaporization and, 335, 336  
 immersion coil heat exchanger, 207, 258, 259  
 imported oil, annual value, 18f  
 inaudible pinging, 400, 404  
 incentives  
     alcohol fuel production, 497–498  
     FFV cold-start device, 499  
     regulations and, proposed, 495–501  
 inches of mercury, 213  
 India, 26, 36, 37, 284, 285f  
     methane production in, 298  
 industrial agriculture, 29–31  
 industrial distillation. See continuous distillation  
 industrial electricity meter, 485  
 industrial-grade alcohol, from distillation, 206  
 insecticides  
     biological/organic approach to, 170–171, 317f  
     biology and, 45  
     chive concentrate as, 291  
     herbicides increasing sales of, 131  
 Institute for Technological Research (Brazil), 450  
 insulation  
     firebox, 221, 221f, 222–223  
     holding tank, 260f  
     manifold, 413, 422  
     mineral wool, 190, 222, 223, 413  
     packed column/tank, 204–205  
     straw, 190, 221f, 444  
     tank, 190, 223, 260f, 307, 444  
 intake air, heating of, 410–411  
 integrated alcohol production, fuel co-op, 510–512  
 intercooler, 335  
 internal combustion engine (ICE), 63, 332, 407  
     cogeneration from, 442, 444  
     first, 11  
     fuel-cell v., 64  
     fuel/feed plant plumbing and, 254  
     hydrogen gas fueling, 64  
     methane in, 266  
     waste heat from, 442  
 inulin, 94, 150f  
 iodine test, 95, 101  
 Iogen Corporation, 134, 135  
 Iowa Petroleum Council, 17f  
 Iraq  
     radiation and, 60  
     U.S. occupation of, 51  
 irrigation, drip, 303, 303f, 317

isoamyl nitrate, 451  
isopentane, 394

jackets, tank, 189–190, 190f

Jaguars, 381

Jalapa, Mexico, 87

Japan, 17, 435

car company engine selling in, 443

Jefferson, Thomas, 492

Jerusalem artichokes, 147–152, 489f, 490–491

leaf protein extraction of, 147

planting, 149

processing, 148f, 151–152

yields for, 150

joule, 351

juice press, 85, 85f, 86

juicing

benefits of, 85–86

feedstock fermentation, 85–87

Kazakhstan desert, 54

kelp. See marine algae

kelp solution, 89, 156–157

kerogen, 54, 62

natural gas energy to produce, 52–53

kerosene, 12, 408, 447

keyline layout, 71

kick-starting, motorcycles, 423

King, Martin Luther, Jr., 3, 5, 112

K-Jetronic fuel injection, 383

Klotz, 426

knock sensor, 405f, 434

Koolmotor Alcohol Blend, 16

KQED, 1, 2–4, 457, 479, 479f

Kyoto treaty, 499

lactic acid, 115

lactose, yeast and, 178, 305

ladder tanks, 269, 272f

laminar flow, 259

Laminaria japonica, 153

laminarin, 153, 155

land

alcohol fuel production, 27–29, 157

arid, 27, 125, 164

availability of, 26–29

energy crops and, 119, 128

myths about available, 26–29

organic matter farm, 39

sloped, 236

U.S. agricultural use of, 26–27, 27f, 31–32,

31f

large production plants

alcohol yield of, 458

distiller's feed usage in U.S., 284

energy for, 278

fermentation process differences in, 96

yeast separation in, 306

lathe chip packing, 195f, 196

lawn mowers. See utility engines

layers (poultry), 283

layout, distillery, 234f, 237–239

lead, 355

gasoline as containing, 355, 357, 358

as octane booster, MegaOilron use of,

355

tetraethyl, 357

use of, world, 358

leaf protein concentrates (LPC), 147

leaf protein extraction, 147

Lee, Henry, 10

legal considerations, 465–478  
alcohol fuel definition, 430, 500  
BATF/Treasury Department and, 469–471  
E-98/E-85, 468  
engine conversion, 386–387, 467–469  
LLC, 459, 462, 466–467  
tax benefits and, 466

Leggett, Jeremy, 63

legislation, alcohol fuel, E-85 and, 430

*Lentinus* (mushroom), 287

Liberator 925 six-inch distillery, 198f, 458

Libya, oil accident in, 19

lichens, 152–153

lighting, 341

lignin, 31, 287–288  
cellulose and, 129, 287

lime, 226–227, 354  
forms of, 117

limited liability corporation (LLC), 459, 462, 466–467, 514

liquefaction, 98–100  
barley malt variation in, 115

liquefied natural gas (LNG), 56–57  
explosions of, 57

liquid alcohol heat, 210

liquids/weights equivalents, measurement of, 541f

litmus paper, 92, 92f

livestock feeding, 86, 279–283, 316

L-Jetronic fuel injection, 383

LLC. See limited liability corporation

LNG. See liquefied natural gas

loading up effect, 196

loans  
avoiding bank, CSE and, 504  
proposed incentive, 497

Long, Russell, 52

long-term fuel trim, 328

low wine, 203, 204, 206

lower boiling point, energy from, 210–214

lubrication/lubricants  
biodiesel, 426–427, 450–451  
crankcase oil, 428, 435  
diesel engine, 450  
ethanol v. gasoline and, 344, 356  
four-stroke engine, 428  
petroleum v. synthetic, 428  
polyol ester, 428, 468–469  
small engine, 425  
synthetic, 428  
synthetic oil, 426  
two-stroke engine, 426–427, 428  
vegetable oil, 426

*Lumbricus rubellus*, 295

mad cow disease, 281, 316

maintenance  
costs for fuel/feed plant, 460  
packed column still, 197

maltose, 95

maltulose, 100

mangrove swamps, 294

manifold  
design, 366  
equal-feeding, 407f  
gaskets, 412–413  
gauge, 369  
insulation/shrouding, 413, 422  
puddling effect, 370, 370f, 425  
utility engine, 425

manifold absolute pressure (MAP) sensor, 387

manifold vacuum pressure (MVP), 367–368, 369–370, 372, 373f, 530

manifold-to-head gasket, motorcycle, 422

manipulation, market, 463, 498

mannitol, 153

mantles, 341

manual fuel pump, 273f

manual system override, distillation, 200–201, 203–204

MAP. See manifold absolute pressure

mariculture, 294–295

marine algae, 29, 89, 268, 498. See also algae

biodiesel and, 154

CO<sub>2</sub> and, 316

decomposition of, 156

EROEI for, 156

feedstock cultivation of, 153–157

fish production use of, 292–293, 315

global warming and, 35–36, 156, 302

methane effluent feed for, 298

microscopic, 156

solar energy in, 156

solution of, 89, 156–157

marine stoves, 340, 340f

market

CO<sub>2</sub>, 304

FFV, 74

futures, 501

gasoline, 219

manipulation, 463, 498

sugar-alcohol, 71

tilapia, 289–290, 291–292

Martinez-Carrera, Daniel, 42, 131

mash, 11. See also wort

agitation of, 94, 99, 101, 105, 246, 249–251, 481

boiling of, 220, 484

contamination of, 106, 106f, 255, 484, 489

in continuous distillation, 207

dewatering, 236, 237, 263, 264f, 297, 304–305

drying of, 261–265, 263f, 266f

fusel oils in, 208

high-protein, 94

liquid, 217, 297, 481

liquid v. vapor in, 217

particulate, 263

preheating, 207, 208, 219, 259, 260, 483

solids/solubles in grain, 284f

spent, 11, 235, 241, 260, 261, 306, 439, 440, 482

vinasse, 169

viscosity of, 113, 113f, 250, 254

mash byproduct, 79, 80

mash pot, boiling point in, 191

mash pump method, 250

mash transfer, 236, 259–260

plumbing for, 255–256

maximum operating pressure, 202

MBTH method, 348

McCain, John, 432

McKibben, Bill, 68

McMurtry, James, "We Can't Make it Here," 342f

Meadows, Donella, 228

measurement

Btu, 186, 351

conversion tables for units of, 534f–535f

diameter v. area, 368f

drill bit, equivalent sizes for, 367f

energy, joule as, 351

- foot-candles, 41f  
 fuel pressure, 382–383  
 heating value v. energy efficiency, 351–353  
 hectare, 41  
 hydrocarbon, 347  
 liquids/weights equivalents for, 541f  
 mercury inches, 213  
 RVP, 350  
 SSU, 254  
     water column, 267  
 mechanical distributors, timing adjustments for, 401–404  
 mechanical energy, 64  
 mechanical fuel pump, cold-start system, 395–396, 396f  
**MegaOilIron** (oil companies), 1, 74, 356. *See also specific oil companies*  
     alcohol history and, 17  
     alcohol octane avoided by, 358  
     auto company bargains and, 430  
     CAFE credits and, 430–431  
     E-85 and, 463  
     emissions research by, 350  
     ethanol purchase by, 464  
     exploitation by, 19–20, 32  
     gaming of, 501  
     gas station ownership by, 496  
     lead in gasoline and, 355  
     market manipulation by, 463, 498  
     methanol and, 437, 438  
     propaganda of, 17, 327, 463  
     Renewable Fuel Standard and, 20  
     research funding/methodologies of, 347, 520  
     scientists associated with, 358, 520  
     tax credits/loopholes of, 464, 496, 501  
     vaporizing alcohol and, 332  
     war as exploited by, 19–20  
**melon**, 486  
     pulp, 79, 163  
**Mercedes-Benz**, 335, 418, 451  
     M196 Formula One racer, 377  
**mercury**, 293  
     inches of, 213  
     pollution from, 58  
**mesquite**, 27, 157–158, 164  
**metals**  
     clean combustion, 431  
     heavy, 35  
**metering rod**, 383  
**metering system** (metering jet)  
     adjusting, 364–368, 411  
     changing, 368  
     drilling/drill bits, 365–366  
     locating jets in, 364  
     motorcycle, needles in, 422  
     removal of, 365, 366f  
     throttle linkage release, 364  
**meters**, electricity, 445, 485  
**methane**, 73, 297–299  
     boiler/generators, India's, 26  
     CO<sub>2</sub> from, 266, 293, 316  
     collection of, 267  
     DS for, 286, 297, 316, 459  
     hydrates, 61–63  
     marine algae, 157  
**methane digester**, 318  
     butanol alternative to, 440  
     effluent from, 298  
     manure liquefied in, 293  
**methane production**, 265–268, 286  
**bacteria** and, 266, 297  
     cattle manure/DDG for, 293, 298  
     CO<sub>2</sub> from, 266, 293, 316  
     DS for, 286, 297  
     ponds for, 266, 267–268  
     tanks for, 266–267, 268f, 269f  
**methanobacters**, 266  
**methanol**, 66, 437–439  
     auto racer use of, 344, 438  
     corrosion comparison of, 353, 356  
     ethanol v., 334–335  
     gasoline v., 431  
     production of, 437–438  
     properties comparison of gasoline, ethanol and, 345f  
     research and, 343  
     toxicity of, 438  
**methionine**, 124, 283, 286, 288, 313, 314  
**methyl nitrite gas**, 438  
**methyl tertiary butyl ether (MTBE)**, 268, 357  
**metric conversions**, 543f  
**Mexico**, 42, 87, 140  
**M-H zoning**, 471  
**microflora**, 278  
**microlife**  
     chemical fertilizers killing, 45, 130  
     compost and, 285  
     crop yields and, 48–49, 49f  
     plant feeding and, 43–45  
**micro-plant** (fuel/feed), 216, 231–233, 491–492  
     economics of, 458–465, 460–461f  
     electricity for, 233  
     equipment for, 231–233, 239–241, 264  
     income/profitability of, 320, 320f  
     legal considerations for, 465–478  
     model for, 311–321  
     pumps for, 251, 251f  
     tanks for, 241  
     tax credits for, 497  
     water for, 233, 252–253, 256  
**microturbine cogenerators**, 443, 443f  
**microwave energy**, 186  
**microwave vaporization**, 339  
**Midwest**, crop rotation in, 40  
**mileage**, 263, 531, 532  
     Acura Integra conversion and, 531, 532  
     compression ratio influencing, 359–360  
     diesel engine, 449  
     doubled, 352  
     E-100, 432  
     ethanol v. gasoline, 351–353  
     FFVs, 432, 434  
     heating value and, 351–353  
     hybrid vehicles, 328  
     methanol and, 438–439  
     stoichiometric ratio influencing, 388  
     vaporized alcohol engine, 332–333, 352, 410  
**military**  
     aircraft testing by, 339  
     in Mideast, costs of, 496  
**milk coolers**, 248f, 485, 485f  
**milk production** (animal), distiller's feeds increasing, 281  
**Millar, Bill**, 32  
**milling**, 96  
**mineral wool**, 190, 222, 223, 413  
**Minnesota**, prairie polyculture study in, 42  
**misconceptions**. *See myths*  
**MMT** (manganese-based chemical compound), 356
- Mobil Oil**, Pimentel's employment with, 520  
**mobile pump**, 255  
**mobile vacuum still**, 212f  
**Model A**, 12, 429, 430f  
     distributor, 400f  
**Model T**, 12, 429  
**molasses**, 159–160, 486, 544f  
     yield for, 159  
**molecular sieves**, 227  
**Monbiot, George**, 414  
**monoculture**  
     birth of, 29  
     ethanol studies and, 31  
     palm oil, 73  
**Monongahela**, Revolutionary War and, 9–11  
**Monsanto**, 46, 48, 49, 131  
**Monterey Bay Sanctuary**, 493  
**moonshine still**, 191–192  
**moonshiners**, 11, 282, 306  
**Moran, Terry**, 197  
**Mother Earth News**, 2, 423, 469  
     hot-oil furnace/distillery, 185f  
     pollution study by, 347  
**motor agitators**, 249, 254  
**motorcycles**  
     cold-starting, 423  
     engine conversion of, 421–423  
     fuel lines in, 423  
     Harley, 426  
     hose/clamp drilling on, 423  
     needle diameter reduction on, 422  
**Mount Shasta**, continuous distillery in, 486–489  
**MTBE**. *See methyl tertiary butyl ether*  
**mulch**, coffee byproducts as, 141  
**multiple-canopy strategy**, 130–131  
**multi-port EFI systems**, 381  
**mushroom(s)**, 131, 140–141  
**mushroom cultivation**, 31, 42, 286–289, 314f  
     animal feed and, 288, 314  
     buildings for, 313–314  
     in micro-distillery model, 312, 313–314  
     substrate preparation for, 288–289, 314  
**mutagen**, 56  
**MVP**. *See manifold vacuum pressure*  
**mycelia**, 48  
**mycorrhizae**, 43  
     chemical fertilizer killing, 130  
**mycorrhizal symbiosis**, 43  
**Myrick, Herbert**, 170  
**myths**. *See also propaganda*  
     abiotic oil, 61  
     alcohol fuel, 24–37, 344–360  
     ecology, 29–31  
     emissions, 347–351  
     energy returned on energy invested, 24–26, 519–524  
     ethanol engine performance, 344–360  
     food shortage, 31–32  
     fuel consumption, 36–37  
     land availability, 26–29  
     mileage, 351–353  
     pollution, 34–36  
     sewage, 297  
     taxpayer cost/benefit, 32–34
- Nahuatl people**, Mexico, 42  
**National Aeronautics and Space Administration (NASA)**, 56, 332, 339  
**National Fuel Ethanol Workshop**, 173  
**National Renewable Energy Laboratory**, 343  
**National Research Energy Laboratory (NREL)**,

- 431
- natural gas, 452  
conversion into electricity of, 190  
heating with alcohol v., 446  
kerogen production and, 52–53  
liquefied, 56–58  
methane hydrate as, 61–63  
octane rating of ethanol v., 435  
natural gas condensates (NGC), 35  
cold-starting and, 392  
gasoline containing waste, 350  
Nazis, 18  
neat ethanol  
air pollution lessened by, 350  
research data for, 343  
Nebraska, corn yield of, 48–49  
neighbors, 475–476  
neoprene, 354  
net cooking energy consumed, 114, 114f  
net metering, 445  
net primary productivity (NPP), 30  
New York City EPA, 347  
New Zealand, 70, 147  
New Zealand Ruakura Agricultural Research Station, 147  
NGC. See natural gas condensates  
Nicaragua, 141  
Niels Bohr farm, 511  
niro palms, 160–162  
nitrile elastomers, 355  
nitrogen  
biofilter for, 291  
comfrey source of, 142  
elevated, 156  
emissions of, 52  
fish emulsion, 292  
hemp and, 133  
methane digester effluent producing, 298  
plant sugar levels and, 91  
river of, 154f  
nitrogen-fixing, 44, 44f, 158, 163, 292  
nitrous oxides (NOx), 35, 329, 330f, 331, 347, 410  
nonphytate phosphorus, 282  
nonprofit organizations, 466  
NOPEC fuel cooperative, 491–492  
North Sea oil field, 20  
NOx. See nitrous oxides  
NPP. See net primary productivity.  
NREL. See National Research Energy Laboratory  
nuclear power, 59–61, 63, 486  
hydrogen and, 63–64  
wood heat v., 221  
nuclear power plants, 59–61  
abolishing, 500  
cost of, 61  
proposed, 54  
reactors, tubes in, 247  
nuclear transportation accident, 59, 59f  
number drills, 364, 366f  
nutrient(s)  
adjustments, 89–90  
concentrated, distillation producing, 277  
co-product, 279f  
fish water, 291, 317  
mash, grain example composition of, 284f  
methane digester effluent, 298  
mushroom, 286  
yeast requirements of, 89, 104–105
- OBDII. See onboard diagnostics  
oceans, global warming and, 186  
octane, 12, 36  
definition of, 358  
enhancing, 357–358, 427  
lead use for, 355  
methanol, 438  
natural gas v. ethanol, 435  
oil quality and, 357  
pinging and, 351f  
propane, 435, 436  
quality of, 337, 415, 436  
reformulated gasoline, 426
- octane number, 358  
Ogallala Aquifer, 71  
oil. See also petroleum  
abiotic, 61  
annual cost of imported, 18, 18f  
barrels per day, 2004, 51  
castor, 426, 451, 452  
consumers of, 41f  
consumption/origin, 41, 41f  
contaminated, 373, 408  
conventional, 52, 54  
EROEI of, 25  
fusel, 208, 354  
heat source based on, 189–190, 189f, 446  
palm, 73, 160  
profitability of gasoline v., 350  
quality of today's, 357  
reserves of, world, 15f, 33f, 38n29  
shortage of, 1970s, 343  
subsidies for, 32–33  
synthetic, 353, 415, 426  
vapor, 393  
Vietnam and, 19
- oil companies. See MegaOilron  
Oil Depletion Allowance, 500  
oil extraction, tar sands, 52–53, 53f  
oil processing  
inefficiency of, 30  
tar sands, 52–53  
toxic waste from, 55–56, 392  
oil shale, 52, 54–56, 62  
oil tankers, 52  
oil wells  
CO<sub>2</sub> pumped into, 111  
ethanol plant near, 111  
onboard diagnostics (OBDII), 435, 469  
Ontario, Canada, CO<sub>2</sub> enrichment in, 301, 304  
OPEC. See Organization of Petroleum Exporting Countries  
open compressors, 212  
open loop, 380  
organic agriculture, 46–50. See also permaculture; polyculture  
China's, 315  
corn, 46–47  
vegetables, 317  
organic matter, 43  
compost and, 40, 286  
farmland %, 39  
Organization of Petroleum Exporting Countries (OPEC), 2, 19, 21, 32, 52  
osmotic pressure, 87  
Otto, Nicholas, 11  
outlet plugging, 255  
overheating, distillery tank, 245–246  
overstory crops, 138  
oxygen
- alcohol amount of, 345f, 347  
methanol, gasoline, ethanol comparison of, 345f  
oxygen sensor  
catalytic converters and, 379–380  
engine conversion for, 356  
FFV, 432  
fooler technology for, 388, 389f  
fuel injection and, 379–380  
voltage of, 388f  
oxygen standard, 355  
oyster mushrooms, 31
- packed column still, 195–205, 202f  
column control factors for, 197, 199–204  
cooling coils in, 199  
maintenance for, 197  
manual system override in, 200–201, 203–204  
packing materials for, 195f, 196  
perforated plate shared with, 209  
temperature control factor in, 197, 199–201  
temperature in, 197, 199–201  
vapor pressure control factor in, 201–204  
packing gland, 246  
packing materials, packed column still, 195f, 196  
Pagliuso, Josmar, 397, 416  
pall ring packing, 195f, 196  
palm oil, biodiesel from, 73, 160  
palms, 100f, 160–163  
paper production plants, 133, 137  
Paretsky, Sara, 237  
particulate emissions, 348  
pastry waste, 177  
patents, vaporized alcohol carburetion system, 332  
Patzek, Tad, 297, 519–521  
Paynter, Bill, 336f, 338–339  
PCBs. See polychlorinated biphenals  
PCV. See positive crankcase ventilation, 347, 393  
Peak Oil, 34, 53, 53f, 155, 316, 350, 421  
peak power, 336  
peakers, 63  
pectin, 287  
pectinase, 90, 139–140  
Percy, Charles, 21  
perforated plate column still, 194–195, 207, 207f  
performance standard, 512  
perfume, 208  
permaculture, 308, 311, 545–546. See also polyculture  
Brazil's, 71  
CO<sub>2</sub> and, 302, 312  
fertility and, 40  
fossil fuel dependency and, 39–50, 298  
green revolution and, 39–40  
profitability, 49  
sulfur emissions and, 58  
tree use in, 138  
waste eliminated by, 277, 308  
yield and, 24  
permaculture production system, 44, 44f  
permeation emissions, 16  
evaporative v., 350  
MegaOilron's research focus on, 350  
Permian-Triassic extinction, 62  
permits, 469–471  
filling out, 471, 475

- fuel/feed plant, 469–471, 472–474/  
 zoning, 476  
 pesticides, 45–46  
     estrogenic, 30  
     polyculture and, 30, 46, 294  
     Roundup herbicide and, 131  
     shrimp shell as natural, 294  
     toxicity levels of, 46  
 Petrosas, 70  
 petroleum  
     additives, 392  
     annual cost of imported, 18, 18/  
     CO<sub>2</sub> from, 61  
     flashpoint of synthetic oil v., 415  
     lubricants, 428  
     precursor to, 56  
     use of, actual/projected, 36, 36/  
 petroleum reserves, world, 15/ 33f, 38n29  
 pH  
     corrosion and, 353–354  
     definition of, 84  
     glucoamylase, 100  
     liquefaction and, 99  
     yeast and, 104  
 pH correction, 91–93, 99, 104, 108, 115  
     acids for, 115  
     distillation, 204  
 pH meter, 92, 92f  
 phase separation, 225–226, 356–357, 357f  
 phase-change energy, 186–187  
 Philippines, 70  
 Phillips, Utah, 322  
 phosphoric acid, 115  
 phosphorus, 298  
 photochemical smog, 348  
 photosaturation, 40–43, 41f  
     preventing, 42  
     sugarcane, 168, 168f  
 photosynthesis, 40–43, 83  
     algae and, 292  
     CO<sub>2</sub> and, 35, 40, 42, 300, 302–303  
     extending, 42, 302–303  
 pigs, distiller's feeds for, 282–283  
 pigweed, 135  
 pimelon (wild watermelon), 163  
 Pimentel, David, 25, 280, 297, 351, 519–524  
     false assumptions in energy balance  
         research of, 519–524  
     farm equipment in studies of, 519f,  
         521–524  
     misrepresentations of, 519–524, 521f  
 pin vise drill, 365, 366f  
 ping pong, 334, 400, 404, 415, 418, 433  
     causes of, 351f, 358  
     octane/compression ratio and, 358–359  
 pipe friction, pressure loss from, 536–539f  
 pipe/piping, 542f  
     bacteria in, 255  
     data for standard/extra strong, 542f  
     fittings for, 245, 257f  
     methane production, 267  
 Piper Cub aircraft, conversion of, 338–339  
 piston, 417  
     assembly, 417f  
 pitching yeast, 108–109  
 plantations, sugarcane, 30, 70, 71  
 plant life. See also photosynthesis  
     animal feed from, 287  
     biology of, 40–45, 83–84  
     CO<sub>2</sub> enrichment of, 300, 301, 302–303,  
         304, 311f  
     CO<sub>2</sub> levels for, 300–301, 302  
 feeding of, 43–45  
 forage, 147  
 photosaturation of, 40–43, 41f, 168, 168f  
 sequestered CO<sub>2</sub> of, 35, 42  
 sugar-levels and, 91  
 understory, 142, 158, 163  
 xerophytic, 120  
 plants. See also fuel/feed plants; nuclear  
     power plants; still(s)  
     food processing, 492  
     paper, 55, 133  
     sugar/alcohol, 72  
 Pleath, J.W., 353  
 Pleurotus (mushroom), 287  
 plumbing, 236, 253, 254–256  
     hard, 234, 253, 256, 257f  
     mash transfer, 255–256  
 points, 400  
 polar liquid, 350  
 pollution, 34–36. See also air pollution  
     acridine and, 56  
     Brazil's drop in, 348  
     EPA and, 467  
     ethanol v. gasoline, 347  
     groundwater, 268  
     mercury, 58  
     regulations on, 351, 421  
     research on, 347  
     wood smoke, 224  
 polychlorinated biphenals (PCBs), 293  
 polyculture  
     alcohol production and, 29, 39–40, 42  
     cellulose and, 28, 29, 512  
     pests/weeds and, 30, 46, 294  
     photosynthesis and, 40–43  
     yields and, 42  
 polyol ester lubricants, 428, 468–469  
 ponds, methane production using, 266,  
         267–268  
 poor soil, crops suitable for, 122  
 port fuel injection, 369, 407, 423  
 porting, 413  
 positive crankcase ventilation (PCV), 347,  
         393  
 positive displacement pumps, 251, 252, 254  
 post World War II, 19–21  
 potassium  
     methane digester producing, 298  
     sugarcane and, 298  
 potato alcohol, 170  
 potentiometer, 383  
 poultry, distiller's feeds for, 283  
 power. See also cogeneration; electricity  
     fuel/feed plant operation, 72, 254, 265–  
         266, 278, 286, 298  
     pumps and, 254  
 Power Politics (Roy), 23–24  
 power valve actuator, 373f  
 power valve adjustment, 372–373  
     carburetors, 372–373  
 practical boiling points, 191f  
 prairie alcohol, corn v., 42  
 preheating  
     fuel, 407–410, 408f  
     mash, 207, 208, 219, 259, 260, 483  
 pre-ignition, 334, 359, 400, 415  
 premalting, 95, 97–98  
     barley malt variation in, 115  
 preprocessing equipment, 239–241  
 pressure  
     azeotropic distillation and, 228  
     boiling point and, 187, 209  
 column v. perforated plate, 207  
 heat transfer rate and, 188  
 metric-English units for, 542f  
 pipe friction loss of, 536–539f  
 table of various types of, 540  
 pressure gauge, 201f  
 pressure regulator, 267  
 pressure relief valve, 233  
 pressure swing vacuum regeneration, 227  
 pressurized steam systems, 189–190  
 price  
     alcohol fuel, 459, 463, 501  
     gasoline, 33, 432  
 prickly pear, 164–165  
 primary products, 458  
 prion, 281  
 privatization, 55, 58  
 process heat, 317–318  
     low-grade steam for, 211  
     methane for, 316  
 profitability  
     crop rotation/permaculture, 40  
     distiller's feeds, 281  
     earthworm farming, 296  
     integrated livestock/greenhouse farm,  
         317  
     integrated production in, 511–512  
     micro-plant, 320, 320f  
     oil v. gasoline, 350  
     permaculture, 49  
     vehicle, capitalism and, 338  
 progressive cavity pump, 252, 253f  
 Prohibition, 13  
 Project Gaia, 340, 341  
 Project On Government Oversight, 32  
 proline, 280  
 proof gallons, 471  
 proof hydrometer, 203f  
 proof percentages. See also alcohol yield  
     air temperature and, 226  
     for alcohol auto fuel, 191, 197, 404, 425  
     atmospheric still, 214  
     azeotropic mixture, 225  
     boiling point and, 190–191  
     column height to diameter ratio and,  
         196–197, 207  
     corrosion and, 353  
     dry alcohol, 225–226, 228  
     for electricity generation, 197  
     fuel injection requirement for, 379  
     ignition timing and, 404  
     low wine, 204  
     maximum levels of, 225  
     packed column stills and, 196, 229  
     reboiler system and, 217  
     required, alcohol use determining,  
         196–197  
     two-stroke engines and, 426  
     utility engines and, 425  
     vacuum stills, 214, 483  
 propaganda, 24–37, 477. See also myths  
     alcohol history and, 16, 17  
     emissions research, 350  
     market manipulation and, 463  
     pricing, 463  
     vehicle performance and, 327  
 propane  
     alcohol fuel mixed with, 435–436  
     boilers, 488–489, 488f  
     cold-start devices using, 392f, 394f, 395  
     octane rating of, 435, 436  
     tanks, 216

- vaporization and, 335, 394
- propanol, 437
- protease, 94, 104
- protein
- agriculture and, 31–32
  - alcohol production and, 94, 277
  - algae, 292
  - animal feed and, 122, 138, 286–287, 293
  - feedstock sources of, 122, 138, 158, 286–287
  - filtration, 179
  - leaf protein extraction of, 147
  - mushroom, 287–288
  - protected, 280
  - shrimp, 294
  - single-cell, 304–306, 305f
  - urea, 278
- protests, 493
- Pseudomonas syringii*, 135
- public utility
- electricity, 445, 446, 485
  - regulations, 445
- Pufahl, Jim, 335
- pulp
- feedstock fermentation and, 87–88
  - melon, 79, 163
  - wort as, 84
- pump cart, 255f
- pumps, 254, 254f
- alcohol, 72f, 333
  - distillation agitation, 251–254, 251f, 252f, 253f
  - manual fuel, 273f
  - mash transfer, 236
  - power for, 254
  - valves/fittings for, friction loss table for, 543
  - water, 253–254
- radiant heat, 307
- tubing, 317
- radiation monitoring, 59
- radiator, as heat exchanger, 187
- rain dances, 135
- rate of equalization, 187
- Reagan, Ronald, 21
- rebates, 464
- reboilers, 194, 217–218
- recordkeeping, 470
- rectifier, 209
- reflux ratio, 199, 480
- refluxing, 199, 483
- reforming, alcohol, 431
- reforms, regulation, 499–501
- reformulated gasoline
- emissions from, 330f
  - octane and, 357, 426
  - oil quality and, 357
- refractometer, 84f, 85, 90, 90f, 91
- refractory wool, 413
- refrigerant heat, 212, 213, 215
- refrigerators
- alcohol-fueled, 341, 447
  - waste heat from, 212
- regulations, 430. See also legal considerations; permits
- California, 426
  - CARB-style, 467
  - carcinogen, 426
  - on denaturants, 470, 500
  - distillery size and, 469
  - emission, 351, 421
- energy bill, 2005, 462–463
- ethanol incentive program, 463–464
- FFV, 500
- fire code, 471, 476
- guidelines for proposing new, 478
- lead example of, 358
- mercury, 58
- micro-generator, proposed, 500
- oil company gaming and, 501
- oxygen standard, 355
- pollution, 351, 421
- proposed incentives and, 495–501
- public utility, 445
- radiation monitoring, 59
- reform of, 499–501
- small/utility engine, 421
- tax, 465
- zoning, LNG, 57
- Reid vapor pressure (RVP), 327, 350, 360
- Relyea, Rick, 131
- renewable energy credits, 462–463
- renewable fuel. See also biofuel
- 1970s and, 20–21
  - federal tax credit for, 496, 497
  - oil companies and, 496
  - state incentive programs for, 2, 463–464
  - transition to, 495–496, 495–505
  - U.S. supply of, 497
- Renewable Fuel Standard (RFS), 20, 463, 499
- research
- alcohol fuel safety, 356
  - alcohol fuel v. gasoline, 343–360
  - aldehyde, 348
  - energy balance, Pimentel's, 25, 519–524
  - energy corporations', 343, 347, 348, 358
  - evaporative v. permeation emissions, 350
  - flawed, 25, 348, 351, 519–524
  - funding for, 343, 520
  - independent v. energy corporation, 347
  - mileage, 351
  - oil company methodologies in, 347
  - Shell Oil's HE-100 field trial, 356
- retail credits, 496
- Revolutionary War, 9–11
- RFS. See Renewable Fuel Standard
- rhizome yield, 127
- Rhizopus*, 94
- rhizosphere, 43
- rice, CO<sub>2</sub> enrichment of, 302
- river of nitrogen, 154f
- road base, 238
- roadside spraying, 493
- roadsides, energy crops and, 128
- Rockefeller, John
- Ford and, 11–14
- rocket still, 221f
- Rogers, Will, 322
- root crops, alcohol yield of, 145
- rototillers. See utility engines
- Roundup herbicide, 45
- amphibians killed by, 131
- Roy, Arundhati, *Power Politics*, 23–24
- rubber
- butyl, 355
  - smooth bore, 541f
  - synthetic, 18–19
- rumen, 144, 280
- ruminants, 121, 279–280
- running octane value, 357
- RV cams, 416
- RVP. See Reid vapor pressure
- Saab, 336, 418, 434
- Volvo and, 434
- saccharification, 94, 100–102
- saccharometer/refractometer, 84f, 85, 90
- Saccharomyces*, 135
- Saccharomyces cerevisiae*, 84
- safety
- acids and, 115–116
  - alcohol fuel, 356
  - CO<sub>2</sub>, 299
  - ether use, 394
  - fuel heating, 409
  - heat sources and, 218
  - Uniform Fire Code and, 471
  - vacuum still, 214
- safety equipment, acid/base, 115–117, 116f
- sago palms, 78, 100f, 162, 294
- Salatin, Joel, 289
- sales
- alcohol fuel, 33
  - butanol solvent, 439–440
  - cellulosic alcohol/ethanol, 136–137
  - CO<sub>2</sub>, 312
  - cold-start devices, 395
  - earthworm, 295
  - feed, 312
  - fish emulsion, 292
  - mushroom, 288, 314
  - natural gas v. alcohol, 446
  - organic vegetables, 317
  - shrimp, 294
  - single-cell protein, per ton, 306
  - tilapia, 289–290, 315
  - worm castings, 315
  - yeast, 306
- sandwich adapter, 442
- Santayana, George, 21
- Saudi Arabia, 18, 18f, 21, 208
- Saybolt Seconds Universal (SSU), 254
- SBM. See soybean meal
- Schmidt, Lanny, 65
- Schreibman, Martin, 289
- scientists
- industry, 358
  - research choices by, 343
- SCP. See single-cell protein
- Seagram alcohol tractor, 13f
- secondary products, 458
- semi-continuous cooking, 112–113, 113f
- separating solids
- DDG, 481
  - WDG, 279
- sequestered carbon dioxide, 35, 42
- severe reforming, 65
- sewage treatment, 127, 129, 297
- bypassing need for, 278, 298
  - facilities, 127
- shaker table, 263, 264
- shaving heads, compression increase and, 416, 417
- sheep, 281–282
- Shell Oil, 356
- shell and tube heat exchanger, 333
- sherry feedstock, 211
- shiitake mushrooms, 131
- Shook, Les, 489–491, 489f
- shredders, 240–241
- shrimp, 294–295
- Siberia, 153
- side-draft carburetors, motorcycle, 422
- sight tube, 245
- silage, 128, 279

- simultaneous saccharification and fermentation (SSF), 101, 106  
 single-barrel carburetors, 364, 372f  
 single-cell protein (SCP), 304–306  
     farm, 305f  
 Sinopec, 54  
 site, fuel/feed plant, 238–239, 476–478  
     preparation of, 238–239  
 six-carbon sugars (C6 sugars), 133, 137–138  
 six-inch distilleries, 198f, 490f, 503f  
     control coil construction for, 205–206  
     vacuum pump for, 214  
 small production plants, 234–237  
     DDG and, 278–279, 292–294  
     distillation type for, 206, 216  
     equipment for, 234–237, 239–241  
     fermentation differences in, 96  
     methane power for, 286, 298  
     methanol production in, 437–438  
     model, 311–321, 319f  
     pumps for, 251, 253  
     single-cell protein production in, 304–306  
     tank selection for, 241–246  
     WDG separating in, 279  
 smog  
     photochemical, 348  
     tests, 467, 468, 529  
 smoke, deaths caused by, 339, 340  
 smooth bore rubber hose, PSI pressure loss for, 541f  
 snowmobiles, 425  
 Society of Automotive Engineers, 356–357  
 soda can stoves, 340  
 soda pop, 176  
 soft starch, 99  
 soil  
     compost and, 285  
     crops suitable for poor, 122  
     erosion, 48, 166  
     loss, 30  
     microlife, 43–45, 48–50, 49f, 130  
     stillage and, 284  
 solar drying, 262  
 solar energy, 83, 500  
     distillation and, 187  
     marine algae, 156  
     tropical fruit and, 175  
         White House, 21  
 Solar Energy Research Institute, 343  
 solar income, 50  
 solar saturation, sugarcane, 41f, 168, 168f  
 solar vacuum still, 128f, 210  
 solar-hydrogen-fuel-cell engine, 64–66  
 solenoid valve, 103  
 solids, mash solubles and, 284f. See also distiller's dried grains  
 solubles, mash solids and, 284f  
 Sonoma County, distillery example in, 489–491, 490f  
 sorghum, 78  
     sweet, 172–175  
 sour orange trees, CO<sub>2</sub> enrichment of, 302–303  
 South Dakota Corn Growers Association, 325  
 Soviet Union (former), 127  
 soybean meal (SBM)  
     digestibility and, 280  
     distiller's feeds v., 280, 282  
     feedstocks similar to, 120  
 soybean production  
     Brazil's, 170–171
- spark ignition system, 333–334, 411–412, 453–454  
 spark plugs, 411–412  
     history of, 399–400, 400f  
 Spencer, Herbert, 4  
 spent mash, 11, 89, 90, 235, 241, 439, 440, 482  
     as alleged sewage, 297  
     heat exchangers for transferring, 260, 261  
     reusing, 304  
     yeast separation from, 306  
 sperm count, estrogenic pesticides lowering, 30  
 spirulina, 292–293  
 splitting columns, 229f  
 springtails, 43  
 squash, 176  
 SSF. See simultaneous saccharification and fermentation  
 SSU. See Saybolt Seconds Universal  
 stainless steel  
     scrubbing pads, 196  
     tanks of, 241–242, 271  
 Standard Oil, 16, 18–19, 322  
 starch  
     calculating grain, 112  
     energy from, 83–84  
     flinty, 95  
     fruit v., 80  
     soft, 99  
     yield calculation for, 112–113  
 starch method, 95–102, 109f. See also batch fermentation method  
     agitation, 99, 101, 105  
     conversion (saccharification), 100–102  
     hydrolysis, 98  
     liquefaction, 98–100  
     milling in, 96  
     overview of, 95–96  
     pH correction in, 99, 104, 108  
     premalting, 95, 97–98  
     slurrying process in, 96–97  
     sugar dosage in, 105–108  
     sugar testing in, 90, 91, 111–112  
 starch recipe model, 96f  
 state tax incentives, 2, 463–465  
 steam  
     at atmospheric pressure, 187  
     heat source, 186–187, 189  
     low-grade, 211  
     pressurized steam system, 189–190  
     waste, 201  
 steel  
     China's demand for, 241  
 Steingrabber, Sandra, 58  
 stepping, jet needles', 422  
 still(s). See also distilleries  
     batch, 207, 209  
     column, 193–194, 193f, 194–195, 195–205, 202f, 209, 488–489  
     cooker and, 235  
     doubler, 192–193, 192f  
     fractional, 139  
     history of, 191–194  
     moonshine, 191–192  
     rocket, 221f  
     six-inch column, 198f, 205–206, 214, 490f, 503f  
     solar vacuum, 128f, 210  
     three-inch, 197  
     vacuum, 128f, 210, 214–216  
     stillage, 42. See also distiller's solubles
- compost from, 284–286  
 dewatering, 304–305  
 energy produced from, 298  
 fertilizer from, 283–284, 298  
 methane from, 286  
 small plants', 292  
 thin, 278, 284, 286, 293, 297, 298  
 whole, 280–281  
 stoichiometric ratio, 364  
 storage  
     alcohol, 226, 232, 268–274, 268f, 271f, 476, 500  
     barley malt, 114  
     CO<sub>2</sub>, 301  
     DDG/DDGS, 279  
     diethyl ether, 394  
     distiller's feeds, 279  
     dry/anhydrous alcohol, 226  
     electricity, 444, 445  
     energy, 445  
     feedstock, 77–78, 176  
     greenhouse heat, 301–302  
     mash drying and, 241, 261  
     regulations, 476  
     single-cell protein/bacteria, 306  
     tubers, 150  
     ventilation for, 272–273  
     waste heat, 188–190, 217, 301  
     water, 235, 254  
     WDG, 279  
     zoning issues for, 500  
 stoves, 340, 340f  
 straw  
     insulation using, 190, 221f, 307, 444  
     lignified, 31  
 strip mines, 57f  
 stripper (column), 209, 487  
 strong acid hydrolysis, 132  
 subsidies  
     alleged alcohol, 17, 17f  
     oil, 32–33, 496  
 subsoil, 285  
 substrate, mushroom, 288–289, 314, 316  
 suburban distillers, feedstock selection for, 80–82  
 sucrose, 83, 100  
 sugar  
     alcohol and, dual markets for, 71  
     C6 fermentable, 133, 137–138  
     fermentable, 133, 155  
     glucose, 40, 83  
     soil microlife feeding on, 45  
     in wort, 91  
     xylitol/alcohol as, 136  
     yield calculation for, 111–112  
 sugar beets, 165–167, 298  
 sugar content  
     definition of, 85  
     testing, 90–91, 91f  
 sugar dosage, 85, 105–108  
 sugar method, 85–95, 85f, 86f, 91f  
     enzymes and, 90, 92, 93–95  
     nutritional adjustments in, 89–90  
     overview, 85  
     pH correction in, 91–93  
 sugar palm, 162–163  
 sugar plant generator, 25, 25f  
 sugarcane, 166–171  
     alcohol production from, 171, 211, 298  
     bagasse from, 25, 25f, 71–72, 137, 451  
     Brazil and, 30, 70, 71, 170–171  
     characteristics of, 166–167

growing, 167–169  
harvest/management of, 169–170  
permaculture and, 169  
photosaturation and, 168, 168f  
plantations, 70, 71  
planting, 166–167  
potassium and, 298  
solar saturation of, 41f  
sweet sorghum v., 173  
vinasse of, 169  
world alcohol fuel production and, 29  
yields of, 170–171

sulfur emissions, 52  
  permaculture and, 58

sulfuric acid, 35, 54, 58, 115, 116, 132, 356

Sullivan, Paul, 328

sunlight. See also solar income  
  plant use of, 40–42  
  tropical v. U.S., 41

supercharger, 418

supercritical steam, 65

surplus. See also waste heat  
  CO<sub>2</sub>, 317  
  DS, 320  
  electricity, 444, 445  
  gas, methane production and, 267

swale, 44, 44f

Swayze, Orrie, 325–327, 326f

Sweden, 153, 340, 434  
  E-85 fuel of, 70

Sweeney, Doc, 1

sweet potatoes, 171–172

sweet sorghum, 172–175  
  planting, 175  
  sugarcane v., 173

switchgrass, 130

symplylans, 294

Syn crude Canada Ltd., 54

Synthetic Liquid Fuels Act, 55

synthetic lubricants, 426, 428

synthetic oil  
  flashpoint of, 415  
  low-proof alcohol and, 353  
  lubrication with, 426

synthetic rubber, 18–19

synthetic unleaded gas, 438

Szwarc, Alfred, 74

table sugar, 162–163

tanks  
  agitator, 249f  
  butane, 216  
  cold-start, 337f  
  column size and, 197, 197f  
  cyclone funnel, 223f  
  cylindrical, 243f  
  distillery, 192–193, 197, 197f, 216, 223,  
    223f, 232, 237, 241–246, 243f, 247,  
    249, 250  
  doubler, 192–193, 192f  
  fish production, 291, 315  
  fuel, 268–269, 268f, 269, 269f, 271  
  fuel oil, 217f  
  grounding, 272  
  holding, 260  
  insulation for, 190, 223, 307, 404  
  interior of, 241  
  ladder, 269, 272f  
  methane production using, 266–267,  
    268f, 269f  
  oil tanker, 52  
  plastic, 242–243, 245, 250, 271

position of, plant layout and, 237  
propane, 216  
rpm settings for, 247  
selection of, 241–246  
shape of, 244  
stainless steel, 241–242, 271  
storage, 188–190, 241, 268f  
surplus heat, 188–190  
unagitated, 249  
vertical/horizontal, 249f, 541f  
wooden, 244

tar sands  
  China's bid for, 54  
  oil extraction from, 52–53, 53f

tax benefits/incentives, 33, 461–465. See also  
  tax credits  
  cold-start device, 499  
  consumer, 461  
  MegaOilron exploitation of, 496, 501  
  tax deduction, 461

tax credits, 2, 21, 312, 429, 461  
  alcohol fuel retail, 496–497, 498  
  alcohol production-based, 463  
  alcohol yield and, 462  
  dedicated alcohol vehicle buyers', 499  
  E-85 station, 463, 465  
  federal, 2, 462–463, 496, 497  
  feedstock, 498  
  Jimmy Carter and, 2  
  micro-plant, 497  
  oil company tax havens and, 496, 501  
  proposed, 496–497, 498  
  state, 2, 463–465  
  VEETC, 312, 459, 461–462, 466, 496, 497  
  vehicle, 498–499

taxes  
  beverage alcohol, 469  
  fuel, 464

taxpayers, 32–34

TBI. See throttle body fuel injection

technology  
  appropriate, 516  
  cellulose biomass, 129–138

Teflon, 354

TEGDN. See triethylene glycol dinitrate

temperature  
  batch fermentation, 103–104  
  bottoms, 489  
  enzymes and, 94  
  exhaust, 344  
  fermentation, 84  
  firebox and, 222  
  heat and, 186  
  packed column still, 197, 199–201  
  tank, distillery, 249  
  viscosity as factor of, 544f  
  wort, 94

temperature conversion, table of, 533f

terminology, feedstock fermentation, 84–85

terneplate, 353

test drives, 528–529, 530–531. See also field  
  trial  
  carburetor conversion, 365–366  
  50/50 blend, 329–331, 330f  
  unmodified vehicle, 329–331, 330f

testing  
  aircraft, 339  
  alcohol/biodiesel blend, 451  
  API-rigged alcohol, 16, 25, 26  
  biodiesel lubrication, 426–427  
  iodine, 95, 101  
  maximum operating pressure, 202

methanol-fueled engine, 431  
military, 339  
permeation emissions, 16  
smog, 467, 468, 529  
starch method, 111–112  
sugar, 90–91, 91f, 111–112, 159  
unmodified vehicle, 328–331  
unreliable, 348  
tetrahydrofuran nitrate, 451  
Texas Panhandle, 158  
thermal efficiency, 335  
thin stillage. See distiller's solubles  
Thoreau, Henry David, 62  
300SL gull-wing sports car, 377  
throttle body fuel injection (TBI), 369, 381,  
  407, 423  
throttle linkage, 364  
tilapia, 288, 289–294  
  ADM model for raising, 283, 290–292  
  algae feed for, 292–293  
  biofilter for tanks of, 291  
  market for, 289–290  
  sale of, 289–290, 315  
  WDG for, 315

Tilby Separator system, 170f, 174

Tilby strandboard, 172f

timing tape, 403

toluene, 348, 426

tools  
  alcohol/biodiesel blend testing, 451  
  diesel engine conversion, 451, 452  
  engine conversion, 364, 366, 403, 410  
  fuel injection conversion, 382, 383  
  ignition timing adjustment, 403

topsoil. See soil

torque  
  agitation, 248  
  curves, 335–336, 434

*Torula cremoris* yeast, 179

toxic waste  
  butanol, 439  
  FFVs and, 431  
  gasoline as, 350  
  gasoline production and, 12  
  oil processing, 55–56, 392  
  oil shale, 56  
  paper production plants', 132, 137  
  uranium, 59–60

toxicity  
  gasoline additives, 350, 357–358  
  methanol, 438  
  pesticide, 30, 46

Toyota Prius E-85 test, 328–329

Toyota Tundra conversion, 527–529

tractors  
  alcohol-fueled, 9f, 13f, 486  
  Henry Ford, 13f  
  Pimentel's, 519f, 522–524

*Trametes versicolor* (turkey tails), 288

transnational capitalism, 513

Treasury Department. See Bureau of Alcohol,  
  Tobacco, and Firearms

trees  
  CO<sub>2</sub> and, 302–303  
  mesquite, 157–158  
  multiple-canopy strategy using, 130–131  
  permaculture use of, 138

triethylene glycol dinitrate (TEGDN), 451

Triumph Bonneville, 484

tropical fruits, 175–176

tsunamis, 294

T-tape drip irrigation, CO<sub>2</sub> delivery through,

- 303, 303f  
 tubers, 150  
 tubes/tubing  
     fire, 226–227  
     fuel line, 423  
     heat exchanger, 260f, 333  
     radiant heat, 317  
 turbocharger, 418, 434  
 turkey tails (mushrooms), 288  
 turkeys, 283  
 turnips, 180  
 turpentine, 341, 447  
 twin-column stills, 486–489, 487f  
 two-stroke engines  
     air pollution from, 425  
     cylinder head problem and, 427  
     engine conversion of, 425–428  
     lubrication of, 426  
 Tygon fuel line tubing, 423  
  
 unagitated tanks, 249  
 underground fuel tank, 268–269, 268f  
 understorey plants, 142, 158, 163  
 unfermentable sugars  
     methane and, 135, 170, 299  
     in molasses, 90, 159  
     in testing sugar concentration, 90, 112, 159  
 Uniform Fire Code, 471  
 United States (U.S.)  
     corn agriculture of, 27, 27f, 31–32, 31f, 39–40  
     cost of Mideast occupation by, 496  
     cropland/farmland acreage, 26–27  
     distiller's feeds usage in, 284  
     FFVs of Brazil v., 433  
     gas stations in, number of, 496  
     Iraq occupation by, 60  
     land use in, 27, 27f, 31–32, 31f  
     renewable fuels supply of, 497  
     sunlight in tropics v., 41  
 unmodified vehicles, 325–331  
     alcohol blend for specific, 328  
     emissions comparison for, 330f  
     ethanol performance of, 326, 328–331  
     50/50 alcohol/gas test drives on, 329–331, 330f  
 uranium, 59–60  
 urban distillers, feedstock selection for, 80–82  
 urea proteins, 278  
 urethane (ethyl carbamate), 104  
     fuel lines made of, 355  
 U.S. See United States  
 U.S. Bureau of Mines, 55  
     lead study of, 358  
 U.S. Department of Agriculture (USDA), 27, 28, 48–49, 512  
 U.S. Department of Defense  
     budget, 51  
 U.S. Department of Energy (DOE), 21, 32, 133, 302, 343, 387, 497, 520  
     budget, 32  
 U.S. Department of Homeland Security  
     oil refinery grants from, 32  
 U.S. Federal Power Commission, 57  
 USDA. See U.S. Department of Agriculture  
 utility engines  
     air/fuel ratio in, 424  
     cold-starting, 424  
     counterflow heat exchangers for, 424f, 425  
     engine conversion of, 423–425  
     vaporization and, 425  
  
 vacuum  
     aspirators for, 216  
     boiling points and, 209–210, 210f  
     butane tank for, 216  
     engine, 332  
     gauge, 367, 369  
     manifold, gauge for, 369  
     perfect, 209  
     unintended, 233  
 vacuum advance, 369f  
 vacuum distillery, 215f, 481–484, 483f, 484f, 485f  
 vacuum pump, 214  
 vacuum still/distillation, 134f, 209–210, 209–216  
     advantages/disadvantages of, 214–216  
     atmospheric v., 214, 225  
     bench-scale, 211f  
     heat source for, 210–211, 211–213  
     mobile, 212f  
     popularity/disadvantages of, 209–210  
     proof % in, 214, 483  
     proof levels in, 225  
     solar-heated, 128f, 210  
 Valens, Tom, 69  
 value-added production, 512  
 valves/fittings  
     flow of fluids resistance of, 542f  
     friction loss table for, 543f  
 vapor  
     blow-by, 356  
     leaks, 244–245, 268  
     liquid v., 217  
     oil, 393  
     wood heat and, 221  
 vapor lock, 327, 392, 408, 424  
 vapor pressure  
     boiling point and, 185, 192  
     control factor, distillation and, 201–204  
 vaporization, 210, 268. See also distillation; phase-change energy  
     alcohol fuel, 332, 333f, 341, 399, 409–410, 418, 425  
     azeotropic distillation, 227  
     boiling point and, 332, 409  
     CO emissions and, 333f  
     fuel injection and, 332f, 333  
     history and, 332  
     ignition and, 335, 336  
     microwave, 339  
     patents for, 332  
     utility engines and, 425  
 vaporized alcohol, 66, 331f, 332–333, 335, 341  
     engines, 331f, 332–333, 335, 418, 421f  
     propane carburetors for, 335  
 vaporized alcohol fuel, aircraft and, 336, 338, 339  
 vaporizing alcohol carburetors, 331f  
 variable-compression engines, 433–435  
 VEETC. See Volumetric Ethanol Excise Tax Credit  
 Vegehol Company, 17  
 vegetable oil, engine lubrication using, 426  
 vegetables  
     CO<sub>2</sub> levels for, 301  
     sale/yield of organic, 317  
 vegetation. See plant life  
 vehicle modification. See engine conversion  
 vehicles, 69, 70, 74. See also engine conversion  
     cogenerators as, 444, 445  
     dedicated alcohol, 499  
     dual-fuel, 12, 435–436  
     50/50 alcohol/gas test on, 329–331, 330f  
     flexible-fuel, 74, 225–226, 407–413, 429–435  
     gas-powered, 70  
     household electricity from, 444, 445  
     hybrid, 328  
     petroleum use by, 36, 36f  
     tax credits for, 498–499  
     unmodified, 325–331, 330f  
     warranties on, 468–469  
 ventilation  
     alcohol fuel storage, 270f, 271, 272–273  
     distillation, 247  
     PCV, 347, 393  
 venturi, carburetor, 364, 364f  
 Vietnam, 19, 289  
 vinasse, 169  
 vinasse fertilization, 169, 169f  
 viscosity  
     alcohol fuel, 409  
     engine lubrication and, 428  
     feedstock samples of, 544f  
     mash, 113f, 250, 254  
     SSU of, 254  
     temperature factors in, 544f  
 Viton  
     float needles of, 425  
     fluorocarbon elastomer of, 355  
 VOCs, 355  
 volatile organic compounds (VOCs), 355  
 Volkswagen, 378, 383, 416, 418, 429  
     fuel injection system in older, 381  
     Gol, Brazil, 433  
     TDI diesel engine, 334  
 Volkswagen Rabbit, engine conversion of, 454  
 Volstead Act, 15  
 Volumetric Ethanol Excise Tax Credit (VEETC), 312, 459, 461, 462, 466  
     additional, 496  
     basis increase for, 497  
     eligibility for, 461–462  
 Volvo, 409, 418, 434  
     dual-injection, 452  
     fooler technology of, 386  
 Volvo 850 Turbo, 434  
  
 war  
     MegaOilron exploitation of, 19–20  
     Revolutionary, 9–11  
 warranties, vehicle, 468–469  
 washing, CO<sub>2</sub>, 304  
 Washington, George, 9  
 waste. See also toxic waste  
     feedstock, 80–81  
     glycerin, 440  
     green, 131  
     mushroom cultivation and, 287  
     nuclear, 486  
     permaculture eliminating, 277, 308  
     soda pop, 176  
     use/sources of, 176–178, 392  
 waste gate, 418  
 waste heat, 217, 226–227, 301, 307, 484  
     engine, 442  
     freon system and, 217  
     heat pump, 211–213

- ICEs producing, 442  
 mash drying with, 262  
 storage of, 188–190, 217, 307  
 vacuum distillation using, 211–213  
 WDG drying using, 279  
 waste steam, 201  
 wastewater, crops/suitable for, 126f  
 water. See also hot water  
     alcohol fuel content of, 356  
     boiling point of, 185, 191, 209  
     collection, 71  
     direct solar-heated, 210  
     evaporation of, 71, 278  
     feedstock selection and, 79  
     filtering, 256  
     fish, 316–317  
     fuel compatibility among ethanol/  
       gasoline and, 357f  
     micro-plant use of, 233, 252–253, 256  
     pressure conversion into feet head of,  
       540f  
     runoff, 128  
     storage of, 235, 254, 307  
     warm to hot conversion of, 442  
     whey replacing, 179  
 water filters, 256, 258f  
     biofilter, 291  
 water column, 267  
 water pumps, 253–254  
 water vapor, greenhouse gas, 35  
 watermelon. See pimelon  
 watt, 351  
 "We Can't Make it Here" (McMurtry), 342f  
 weak acid hydrolysis, 132  
 Webb, Earl, 212f  
 weed whackers, 425  
 weeds, 45–46, 119  
     DDGS experiment on, 47–50, 47f  
     mesquite so-called, 157–158  
 weight gain, distiller's feeds and, 280–281  
 West Africa, 163  
 wet alcohol, 70  
 wet distiller's grains (WDG), 278, 281, 282,  
     312–313, 314, 315  
     as fish food, 314  
     separating/drying, 279  
 wheat, distiller's feeds and, 177–178, 280  
 whey, 178–180  
 Whiskey Rebellion, 9–11  
*Whiskey Rebels: The Story of a Frontier Uprising*  
     (Baldwin), 9  
 White, David, 226  
 White House, solar energy panels on, 21  
 whole stillage, animal weight gain and,  
     280–281  
 whole-pulp fermentation, 87–88  
     cooking step in, 88–89  
 wide-open throttle (WOT), 377, 380, 387,  
     528  
 wideband sensor, 380  
 Wilbur, Steve, 127  
 windrows, 285f, 292  
 wine gallons, 471  
 winter squash, 41  
 wiring harness, 388  
 wood, 190f, 233, 459. See also firewood  
     distilleries heated by, 201f, 221–225, 221f,  
       318, 490f  
     firewood Btu/process heat from, 318  
     heat source, 190f, 201f, 202, 221–225,  
       221f, 490f  
 wood alcohol, 437  
 wood smoke pollution, 224, 339  
 wood-burning furnace, 190f  
 wood-burning stoves, 224  
 wooden tanks, 244  
 wood-fired distillery, 201f, 490f  
 World Bank, coffee controlled by, 141  
 world crude oil reserves, 15f, 33f, 38n29  
 world vehicle registration, 36, 36f  
 World War I (WW I), 14–16  
 World War II (WW II), 17–19  
 worm castings, 295–296, 297, 314–315  
 wort, 84  
     sugar content in, 91  
     temperature of, 94  
 WOT. See wide-open throttle  
 WW I. See World War I  
 WW II. See World War II  
 xerophytic plants (low water use), 120  
 xylene (BTX), 348, 355, 426  
 xylitol, 136  
 yeast, 9, 28. See also single-cell protein  
     brewer's, 89–90  
     definition of, 84  
     distiller's, 107, 107f, 135  
     distiller's feeds and, 306–307  
     fatty acids and, 120  
     feedstock fermentation and, 84, 100,  
       102–111  
     fermentation, type used for, 84  
     GMO, 134, 136, 137, 307  
     inulin-fermenting, 150f  
     lactose and, 178, 305  
     nutrient requirements of, 89, 104–105  
     pH and, 104  
     pitching, 108–109  
     replacing corn with, 307  
     spent mash separation from, 306  
     structure of, 106, 106f  
     *Torula cremoris*, 179  
 yeast breeder, 109, 109f  
 yield  
     feed-to-flesh ratio, 288, 295, 296  
     fish production, 293  
     organic vegetable, 317  
     permaculture and, 24  
     plant, CO<sub>2</sub> and, 300–301, 302  
     polyculture and, 42  
     rhizome, 127  
 Zaki Yamani, Sheikh Ahmed, 208  
 Zamack, 354  
 Zinn, Howard, 515  
 zoning  
     fuel/feed plant, 81, 471, 476, 500, 505–  
       506  
     LNG site, 57  
     storage, 500  
*Zymomonas mobilis*, 132f, 133